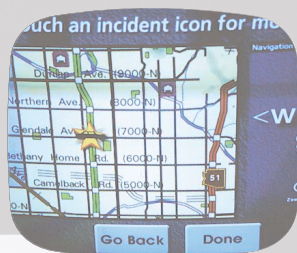


ITS

Asheville Regional Report



North Carolina Statewide Intelligent Transportation System Strategic Deployment Plan



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List of Abbreviations/Acronyms¹

| | |
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| APTS | <i>Advanced Public Transportation Systems.</i> FTA program to focus R&D and funding efforts on ITS technologies composed of five main areas: vehicle operations and communication, high occupancy vehicles, customer interface, rural transportation, and market segment development. |
| ARTS | <i>Advanced Rural Transportation Systems.</i> |
| ATIS | <i>Advanced Traveler Information Systems.</i> Vehicle features that assist the driver with planning, perception, analysis, and decision-making. |
| ATMS | <i>Advanced Traffic Management Systems.</i> An array of institutional, human, hardware, and software components designed to monitor, control, and manage traffic on streets and highways. |
| AVL | <i>Automatic Vehicle Location.</i> The installation of devices on a fleet of vehicles (e.g. buses, trucks, or taxis) that enable the fleet manager to determine the location of specific, AVL-equipped vehicles in the road network. |
| CARAT | <i>Congestion Avoidance and Reduction for Automobiles and Trucks.</i> ATIS/ATMS system in Charlotte, NC involving an advanced transportation management center (TMC) and a subscription-based advanced traveler information system (ATIS) that will provide incident location and response as well as consumer information to its users. This is the original acronym/name for the system and has been replaced with the name "Metrolina Regional Transportation Management System". |
| CBD | <i>Central Business District.</i> |
| CCTV | <i>Closed Circuit Television.</i> |
| Clearinghouse | A clearinghouse stores real-time data for traveler information. The system will include data from system loops, intersections, a detector station, posted incident reports, IMAP incident reports, and real-time bus schedule information. All information whether it is stored locally or remotely, will be accessible from a central location. |
| CVO | <i>Commercial Vehicle Operations.</i> The application of ITS technology to commercial vehicles. |

¹ A number of the definitions regarding communications devices and protocols are from, "Newton's Telecom Dictionary," 16th Edition, Harry Newton, Telecom Books, February 2000.

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| CVISN | <i>Commercial Vehicle Information Systems and Networks.</i> Refers to the ITS information system elements that support CVO. |
| DMS | <i>Dynamic Message Signs.</i> |
| DMV | <i>Department of Motor Vehicles.</i> |
| DSL | <i>Digital Subscriber Line.</i> A generic term for a family of digital lines that provide high-speed data transfer rates across standard telephone lines. Typical bit rates on a DSL connection range from 128kbs to 8Mbs. |
| FHWA | <i>Federal Highway Administration.</i> |
| HAR | <i>Highway Advisory Radio.</i> The transmission of localized traffic advisory messages using 520 AM and 1610 AM frequencies. |
| HOV | <i>High Occupancy Vehicle.</i> Any vehicle containing more than one person. |
| IMAP | <i>Incident Management Assistance Patrol.</i> A service run by the NCDOT to identify freeway incidents and assist emergency personnel. |
| Incident | Any accident, stalled vehicle, or other delay-causing problem on a street or freeway. |
| ISDN | <i>Integrated Services Digital Network.</i> Leased-line data network over telephone lines. A typical ISDN line connects at 128kbs but is more costly in both the end equipment and monthly cost. |
| ISP | <i>Information Service Provider.</i> |
| ISTEA | <i>Intermodal Surface Transportation Efficiency Act,</i> passed by Congress and approved by the President in December of 1991, becoming Public Law 102-240. |
| Kbs | <i>Kilobytes per second.</i> |
| Kiosk | An interactive information center for traffic or travel data located in shopping malls, parking decks, hotels, airports, businesses, transit terminals, etc. It always has interactive computer capability and sometimes has communications linkage to real-time traffic data. |
| Market packages | The FHWA has identified 56 market packages that describe projects in general terms and identifies the information that must be shared between the various components. |
| Mbs/Mbps | <i>Megabits per second.</i> |
| MDT | <i>Mobile Dispatch Technology.</i> |
| MPO | <i>Metropolitan Planning Organization.</i> |

| | |
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| MRTMC | <i>Metrolina Regional Transportation Management Center</i> |
| Multimodal | The use or ability to use multiple modes of transportation; i.e., automobiles and buses. |
| Multiplexers | Electronic equipment that allows two or more signals to pass over one communications circuit. |
| NIA | <i>National ITS Architecture.</i> The NIA is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. |
| PART | <i>Piedmont Authority on Regional Transportation.</i> Regional Transportation between Winston-Salem, Greensboro, and the regional hub at Greensboro Regional Airport. |
| RSVP | <i>Ride Sharing Vehicle Program.</i> |
| RWIS | <i>Roadway Weather Information System.</i> |
| Smart Card Technology | A regional electronic payment system that permits the same method of payment for all transit systems in the region. In addition to permitting travelers to use multiple bus systems without a complicated payment system, Smart Cards enable the various transit and planning agencies to better track ridership, transfers, and other information that can be used to plan for future transit enhancements. |
| T-1 | A digital transmission link with a total signaling speed of 1.544 Mbps. |
| TAC | <i>Transportation Advisory Committee.</i> |
| TCC | <i>Traffic Control Center.</i> Sometimes used interchangeably with Traffic Operations Center (TOC). Strictly defined, TCCs primarily control traffic while TOCs are headquarters for enforcement, operations, and maintenance personnel. TCCs and TOCs often are combined functionally. |
| TCC | <i>Technical Coordinating Committee.</i> |
| TEA-21 | <i>Transportation Equity Act for the 21st Century</i> |
| TMC | <i>Transportation Management Center.</i> |
| TMS | <i>Transportation Management System.</i> |

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| Traffic Signal Systems | A system of interconnected traffic signals (signal controllers) whose major objective is to support continuous movement and minimized delay along an arterial or a network of arterials. |
| TRTMC | <i>Triangle Regional Transportation Management Center</i> |
| TTA | <i>Triangle Transit Authority.</i> |
| User Packages | A list of 63 technology groups that define ITS elements and projects. Where a Market Package defines a general goal of ITS, User Packages define the technologies and deployments that compromise the Market Package. |
| VRAS | <i>Voice Remote Access System.</i> |
| VMT | <i>Vehicle Miles Traveled</i> |
| WIM | Weigh-In-Motion. |

Executive Summary

The North Carolina Department of Transportation (NCDOT) is developing a Statewide Intelligent Transportation Systems (ITS) Strategic Deployment plan. The purpose of this plan is to develop a structured implementation of ITS projects by addressing the immediate and long-term transportation needs of the state.

Developing any statewide plan requires input from many sources, not just from a statewide board or agency. The statewide plan, therefore, is the result of several regional plans, developed through an aggressive stakeholder outreach program that invited the input from well over 1,500 people of different backgrounds. This document represents responses to the statewide plan from the stakeholders in the Asheville Region.

The process that was used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the National ITS Architecture (NIA), a framework that describes ITS components by their functionality and defines how these components are to work together as a system. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the systems, subsystems, and individual elements.

The Asheville Region includes parts of Buncombe and Henderson Counties. Major cities in this region are Asheville, Black Mountain, Fairview, Weaverville, Woodfin, and Hendersonville. Although relatively new, there are several ITS deployments that are either fully functional, in construction, or in the planning stages throughout the Asheville Region.

Through the stakeholder input process, the ITS Strategic Deployment Plan process identified 30 transportation needs. These needs were ranked and the most pressing issues were identified, which permitted the use of the NIA to develop a regional ITS deployment plan and architecture that addressed these needs.

From this process, it was determined that traveler and tourist information, and weather and road conditions were the most urgent issues. Short- and long-term project plans were then determined from the needs. The key component of the Asheville Region ITS Deployment Plan is to develop a central database of traveler information to be disseminated to motorists throughout the region.

The concept of the Asheville Regional architecture is that the City of Asheville and the NCDOT control the traffic operations equipment through the region, and, therefore, has easy access to most of the generated traffic information. External inputs, such as from the Incident Management Assistance Patrol (IMAP) program and the NCDOT statewide program office needs to be accessed, but not generated or stored locally. The concept of the architecture is that the City of Asheville and NCDOT share information both regionally and, statewide to provide information that can be easily accessed from one concise front end.

The regional communications architecture is limited because of the deployments, both existing and planned, and the geography of the region. The system will encompass the existing communications between Asheville and the existing ITS elements, with new deployments providing or improving communication, as necessary.

Introduction

ITS are applications of advanced traffic operations and communications technologies used to improve safety, relieve congestion, and provide better information to travelers. The NCDOT has determined that a blueprint is needed to guide future deployment of ITS throughout the state. This guided deployment of ITS will result in an integrated, cost-effective plan that will increase motorist safety and security, preserve infrastructure and services, ensure transportation system efficiency, provide information, and increase economic development opportunities throughout North Carolina.

The statewide ITS Strategic Deployment plan will consist of a compilation of statewide needs and the needs gathered in nine Regional ITS Strategic Deployment Plans. This Asheville Regional ITS Deployment plan represents one of those nine regional reports. To guide the future deployment of ITS technology in the state, NCDOT is developing a statewide ITS Strategic Deployment plan. This planning process has developed a structured implementation of ITS projects by addressing the immediate and long-term transportation needs in the state. The Department is committed to improving the safety and efficiency of North Carolina's transportation systems, including transit, rail, aviation, bicycle, and pedestrian, as well as highways.

Developing a statewide plan of any sort requires input from a broad base of stakeholders across the board, not just from a statewide board or agency. The statewide plan, therefore, will be the result of three rural and six urban regional plans. Each of these independent but coordinated plans has been developed through an aggressive stakeholder outreach program that invited input from approximately 1,500 people from different backgrounds who have important influence over or opinion on North Carolina's transportation system. This deployment plan takes into account the issues of previously developed area-wide plans as well as multi-modal plans from local agencies.

The Asheville Regional ITS Plan is intended to be a living document that represents a consensus of ideas and concerns from municipalities and other entities in this region, the Division and other NCDOT representatives, and from a diverse group of stakeholders in the North Carolina transportation system.

Introduction to ITS

Increasing the capacity of the transportation network has traditionally been the responsibility of transportation planners, highway designers, and road builders. When a roadway neared capacity, the most frequent response by the NCDOT and other public agencies was to add additional lane miles. Today, as development increases, it is becoming increasingly difficult to add additional lanes without expensive right-of-way acquisitions. ITS has evolved over the last decade to describe a federal emphasis area for transportation systems. ITS also denotes a body of knowledge and discipline area among transportation systems, vehicle systems, and communication systems engineers. The federal program was first authorized by the 1991 Intermodal Surface Transportation Act (ISTEA) and continued by the 1998 Transportation Equity Act for the 21st Century (TEA-21).

The program is supported by all modal administrations within the United States Department of Transportation (USDOT), and by a broad-based professional association called ITS America, which acts as an official advisor on the ITS program to the USDOT and the various administrations of that department and other entities. The National Program Plan for ITS identified the following goals for the national program:

1. Widespread implementation of ITS to enhance the capacity, efficiency, and safety of the federal-aid highway system; to serve as an alternative to additional capacity of the federal-aid highway system; and to enhance development of intermodal connectivity.
2. Enhance, through the more efficient use of the federal-aid highway system, the efforts of several states to attain air quality goals established pursuant to the Clean Air Act.
3. Enhance the safe and efficient operation of the nation's highway system, particularly system aspects that will increase safety. Identify system aspects that may reduce safety.
4. Develop and promote ITS and the ITS industry in the United States.
5. Reduce social, economic, and environmental costs associated with traffic congestion.
6. Enhance U.S. industrial and economic competitiveness and productivity.
7. Develop a technology base for intelligent vehicle-highway systems and establish the capability to perform demonstration experiments, using existing national laboratory capabilities, where appropriate.
8. Facilitate the transfer of transportation technology from national laboratories to the private sector.

ITS, in short, is the use of advanced traffic operations technologies and communication technologies that help increase throughput on existing facilities, improve safety, and provide better and more accurate traveler information to the public.

Additional throughput is occurring in many ways. Advanced traffic surveillance and signal control systems, for instance, have resulted in travel time improvements ranging from 8 to 25%. Incident management programs can reduce delay associated with congestion caused by incidents by as much as 45% and freight mobility systems have shown productivity gains of more than 25% per truck per day².

The following two examples illustrate the beginnings of ITS programs in North Carolina. At the rest areas associated with some of the welcome centers on interstate highways entering the state, traveler information kiosks promote tourist attractions, highway safety messages, highway construction zones, highway services, hotels, restaurants, etc.

These interactive traveler information kiosks provide printed directions to destinations and have the capability of downloading html files that could convey weather information, real-time traffic conditions, incidents, etc. They are a basic, in-place building block for an Advanced Traveler Information Systems (ATIS) in this region. The same type of facility exists at several welcome centers in North Carolina and Tennessee. This private-sector partnership with the state is an excellent example of how ITS is already deployed, and is extremely popular with the tourism industry in the state.

The second example of an in-place component that relates to the ITS program is a freeway assistance service operated by the NCDOT along various portions of I-40 and I-85 in North Carolina. These service patrols (part of the statewide IMAP service that exists in various districts of the NCDOT) provide emergency services such as gasoline, emergency starts, communications, etc. for stranded motorists. They also help to direct traffic around incidents. NCDOT trucks are equipped with communications equipment that could make them effective "vehicle probes" that provide traffic condition information to an information clearinghouse or to one or more of the regional Transportation Management Centers (TMC) in the Triangle, the Triad, or Metrolina.

2 Benefits data is taken from various sources, including: Meyer, M., "A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility," Institute of Transportation Engineers, 1997; Intelligent Transportation Systems: Real World Benefits, prepared for FHWA Intelligent Transportation Systems Joint Program Office, Apogee/Hagler Bailly, January 1998; and, "Review of ITS Benefits: Emerging Successes", Prepared for Federal Highway Administration, MITRETEK Systems, September 1996.

Introduction to the ITS Strategic Planning Process

The process that is used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the NIA. The NIA is a framework that describes what ITS elements and systems do and how the different elements and control centers function together. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.

This section describes the process used to develop the deployment plan in the Asheville Region. A more detailed description of the process, and the elements that make up the process used in the plan development, is provided in the Appendix.

ITS Planning Process

The general ITS planning process is shown in **Figure 1**. This methodology is described in detail in “Integrating Intelligent Transportation Systems within the Transportation Planning Process: An Interim Handbook” (FHWA, January 1998) and in the “Implementation Strategies” volume of the National Architecture. This process follows a direct path towards the development of a deployment plan.

The Regional and Statewide ITS Deployment Plans were developed through a multi-step process that meets the goals and objectives of the NIA. This process invites many stakeholders from multiple agencies to provide input into the planning process. In turn, this input is reduced into general and specific projects that form the overall regional and statewide plans.

It is the intent of the NIA that these regional and statewide plans consist of more than individual projects and technologies. The NIA was developed in response to the deployment of systems that were not compatible with one another by many state and local agencies. In addition, as these systems were being planned, designed, and deployed, neither future expansion nor interagency coordination were considered.

The NIA, therefore, is being used to foster communications between agencies with the goal of developing regional and statewide plans that facilitate interagency communication and coordination, as well as long-range visions that accommodate the future integrated growth of ITS in the Asheville Region.

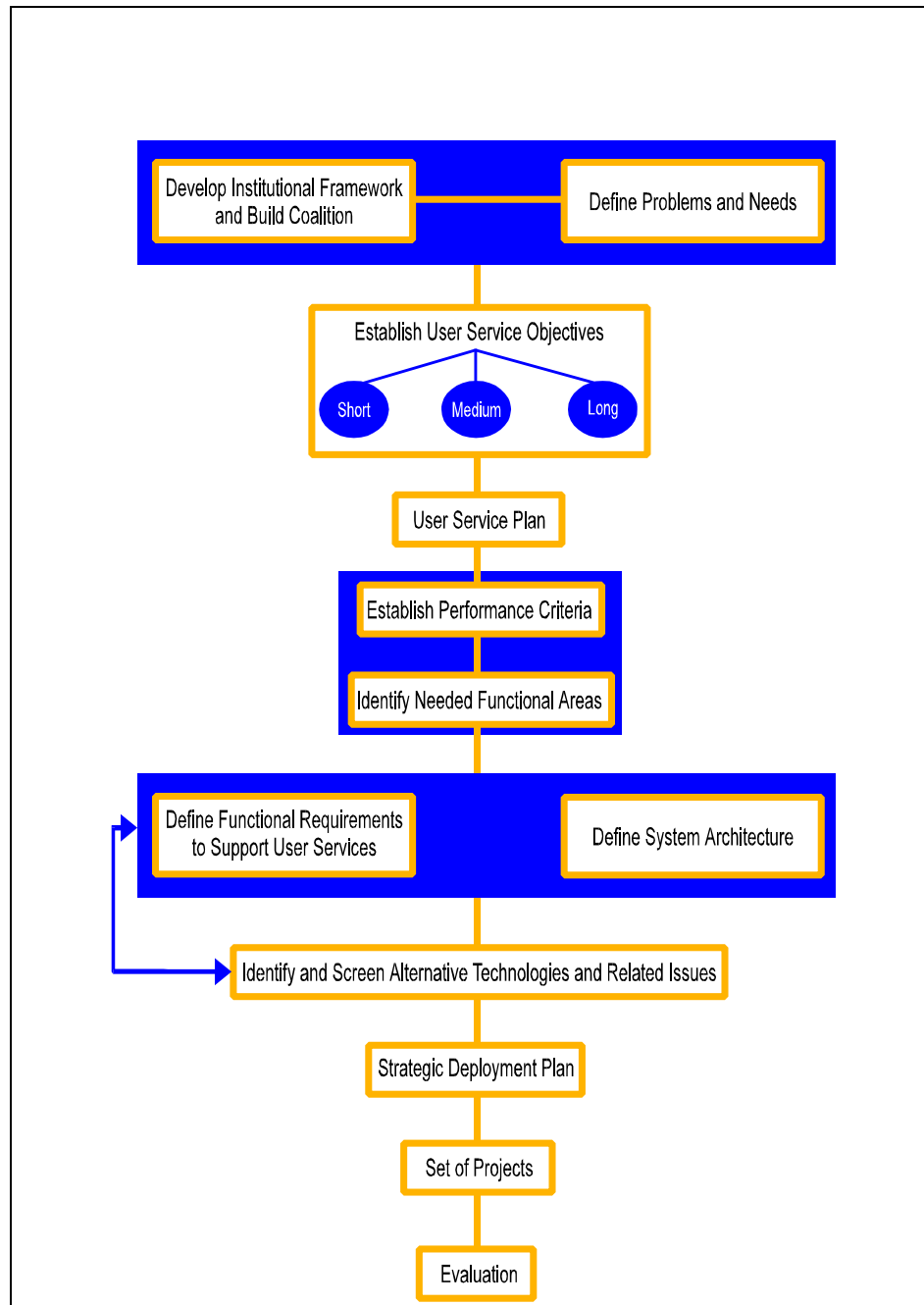


Figure 1. ITS Planning Process.

Background

Project Background

Statewide

The population of North Carolina is growing. As the population grows, so, too, does the demand on the transportation system. This demand is seen throughout the state every day during the peak periods as commute times to and from work continue to increase. Recreational areas are experiencing similar congestion. The projected growth in vehicle miles traveled is shown in **Figure 2**.

The Federal Highway Administration (FHWA) has identified ITS as one of the key responses to congestion mitigation and incident response. ITS is typically more cost-effective than traditional methods of congestion mitigation, such as the addition of new lanes. It also provides tangible side benefits, such as constant data collection for use in planning and operational models.

The NCDOT has identified the need to continue expanding ITS throughout the state. Although there are pockets of deployments (such as traffic signal systems and freeway management systems), these deployments have not been coordinated and do not address all the statewide needs.

The purpose of this document is to demonstrate the need to improve the transportation system, identify ITS solutions, and provide a framework for continued deployment throughout the region and state. This document will be used as part of an overall statewide plan.

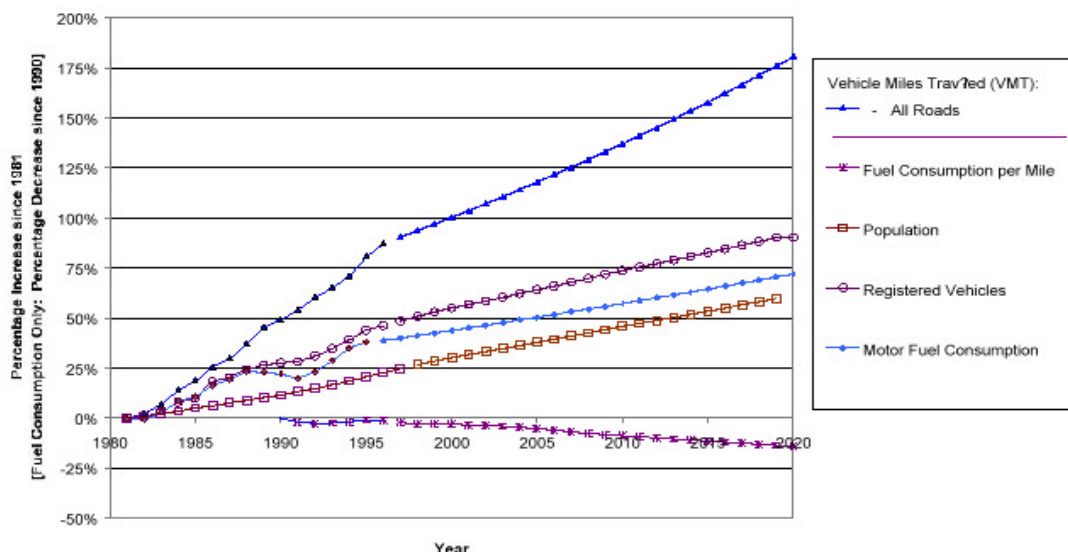


Figure 2. Projection of Key Transportation Indicators for North Carolina.

NCDOT Regional Plans

The North Carolina ITS Strategic Deployment Plan comprises nine regional plans, as shown in **Figure 3** (the I-95 Region is included in the Statewide Report in the interstate system). These regions are grouped according to the ITS needs within each region. For instance, the needs in the Asheville region focus on tourism and weather, while needs in the Interstate region focus on Commercial Vehicle Operations (CVO) and a combination of out-of-state travelers, local commuter travel, and truck routes.

Each of the regions is composed of multiple stakeholders and jurisdictions. These stakeholders include cities, counties, several field divisions within NCDOT, and metropolitan planning organizations (MPOs) for the 17 urban regions in the state. Other interested organizations in urban regions include the police, fire departments, county emergency management agencies, and urban transit agencies.

Through this process, nine regional plans will be developed (the Interstate Region is included as part of the Statewide Plan). All of these plans will be combined to develop a Statewide ITS Deployment Plan that will guide each of the agencies involved as well as NCDOT in the deployment of ITS in the coming years.

Project Goals and Objectives

The Asheville Regional ITS Deployment Strategy must be compatible not only with the regional and local goals set forth by municipalities and counties in the region but also with statewide transportation goals and objectives and the national ITS goals.

Goals of the National ITS Program

The National ITS program was initially created through the ISTEA of 1991, when Congress recognized the critical need to address the aging transportation network. ITS was identified as one of the methods of improving the network.

Since then, the FHWA has been actively pursuing ITS as a key means to improving the safety and efficiency of the transportation system. The National ITS program also has been instrumental in developing the NIA. The NIA is a response to the increased deployment of ITS without clearly defined interoperability between either systems or subsystems.

The program was extended by the ITS Act of 1998, which was a part of TEA-21. This guidance has been effective in the ongoing development and integration of ITS elements.

TEA-21 contained four provisions concerning ITS, which provides funding for the six fiscal years covered by the Act:

- ITS Deployment – small incentive grants to states and local governments to encourage ITS integration and CVO infrastructure deployment

ITS Strategic Deployment Plan

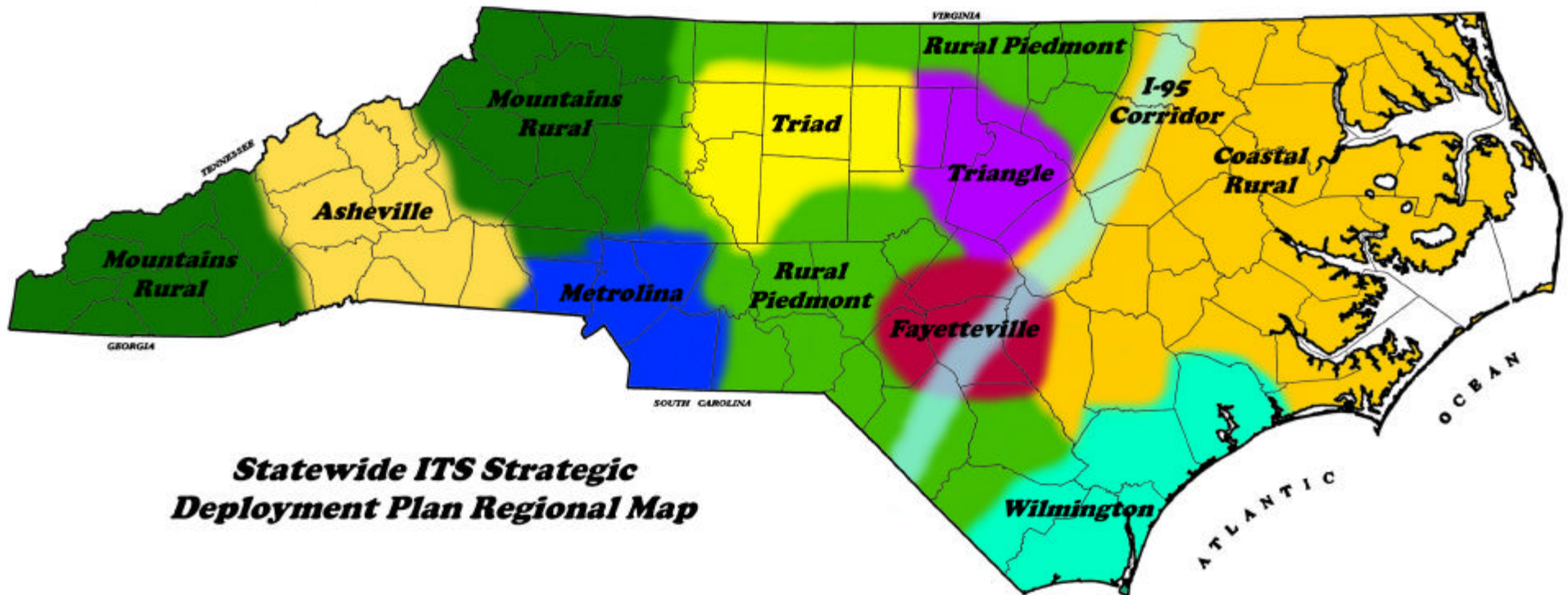


Figure 3. North Carolina ITS Strategic Deployment Plan Regions

Getting You There Safely

- ITS Integration – acceleration of the integration and interoperability of ITS
- CVO Infrastructure Deployment – advancing technological capability and promoting ITS in the trucking industry
- ITS Research and Development – specifically includes funding for ITS services, among other program areas

TEA-21 lists several requirements for project funding, including:

- Contribute to national deployment goals and objectives
- Demonstrate strong commitment among stakeholders
- Maximize private sector involvement
- Demonstrate conformity to NIA and approved ITS standards and protocols³
- Be included in statewide or metro area transportation plans
- Ensure continued long-term operations and maintenance
- Demonstrate that personnel have necessary technical skills

Statewide ITS Goals

The overarching goal of NCDOT's ITS program is to support the Department's mission to "provide and support an integrated transportation system and related services that enhance the State's well-being."

Adding specific goals for the statewide ITS program to this mission statement, the following guiding principles that support this overall mission have been identified:

- Increase motorist safety and security
- Preserve infrastructure and services
- Ensure transportation system efficiency
- Increase economic development opportunities
- Incorporate the ideas and concerns of a broad cross-section of stakeholders in the State's transportation system
- Provide both static and dynamic transportation information, including road conditions, closures, and incident status updates
- Develop a mechanism to facilitate the sharing of information between NCDOT and other public and private agencies

³ Note that at the time of passage of TEA-21, and at present in early 2001, the NTCIP Protocols and other ITS Standards are not all in place and established standards

In addition to these seven goals that have guided the preparation of each of the nine regional ITS Strategic Plans in the State, there is an element of incorporating ITS technologies into the overall toolbox of solutions to transportation problems. The eight goals of the Department, and the objectives that ITS helps to fulfill to meet those goals, are as follows:

- Goal 1: Provide a safe and well-maintained transportation system that offers modal choices for the movement of all people and goods.

ITS Objective: Use ITS technologies to provide information among modes of routes, schedules, incidents, fares, real-time vehicle tracking, and other traveler and shipper information.

- Goal 2: Provide quality customer service.

ITS Objective: Use advanced technologies available in ITS solutions to provide “user friendly” interface between users and transportation systems and services.

- Goal 3: Develop efficient processes to provide quality transportation services.

ITS Objective: Investigate ITS technologies and applications in appropriate projects to provide innovative and flexible solutions and incorporate those technologies where cost-benefit ratios are greater than other solutions.

- Goal 4: Demonstrate responsible stewardship of fiscal resources.

ITS Objective: Compare ITS solutions to new capacity solutions in order to obtain the most cost-effective use of available funding.

- Goal 5: Demonstrate responsible stewardship of other resources.

ITS Objective: Assess the environmental, energy consumption, aesthetic, and other impacts of ITS technology deployment as compared to other transportation solutions.

- Goal 6: Support the development of sustainable, vibrant communities.

ITS Objective: Incorporate the entire ITS stakeholder base into local community efforts to support sustainable community initiatives.

- Goal 7: Maintain a quality workforce.

ITS Objective: Use the technological skills of communications and electronics engineers to upgrade the level of technical expertise in the Department and upgrade other disciplines with cross-training in ITS technology applications.

- Goal 8: Make decisions in a manner that builds trust and mutual respect.

ITS Objective: Develop strong, effective partnerships within the various units of the Department.

Regional ITS Goals

Two types of goals are identified in this document: short-term and long-term.

Short-Term

Short-term goals focus on improving safety and security for the traveling public in all modes of surface transportation, and increasing the quantity and quality of relevant, timely travel and traffic information to the public. Short-term goals also concentrate on building up the “human capital” resources with improved training of personnel in technical disciplines and the development of better, cost-effective ways of establishing partnerships among public agencies and between the public and private sectors to deploy ITS projects in the State. Specific short-term principles to apply as goals include:

- Increasing motorist safety and security
- Preserving infrastructure and services
- Ensuring transportation system efficiency
- Incorporating all stakeholders’ input in the planning process

Long-term

Long-term goals involve many larger projects that actually start in the short-term. These larger scope projects require a significant investment in infrastructure, planning, and coordination. A new, regional TMC, a network of advanced weather information stations, or a statewide weigh-in-motion (WIM) and truck safety system will be considered projects that fit under long-term ITS goals.

Long-term goals include all the principles applied in the short-term, plus:

- Increase opportunities for economic development

National ITS Architecture

All projects that will use federal ITS funds require the development of a regional and/or statewide ITS architecture that meets the needs and criteria set forth by the NIA. As such, the regional and statewide deployment plans require that an ITS architecture be developed. The process of developing an architecture is briefly discussed earlier in this document, in the ITS Planning Process section. A detailed description of the NIA process, goals and objectives is included in the Appendix.

Stakeholder Input Process

Figure 1 shows the multiple steps that are involved in the stakeholder input process. The first step is to establish a stakeholder coalition to develop the vision and define the goals and objectives of the plan, as well as to identify any problems. The stakeholder input process involved multiple meetings and forums with key persons and agencies. Further information on the meetings and attendees is provided in the Appendix.

Despite differences among the regions with respect to how many meetings were held, in general, the meetings in each region occurred in the following order:

Regional Kick-Off/Consensus-Building Meeting. The first task in each region was to hold a regional kick-off/consensus-building meeting. These meetings typically included NCDOT representatives from the region, city and local transportation planners and engineers, and other interested key individuals. The intent of these meeting was to briefly introduce the project and overall statewide goals, customize the deployment planning process for each region, and identify the key public and private stakeholders within the region.

Planning Sessions. Multiple presentations occurred after the project kick-off meeting and prior to the summit meeting in each region. These presentations typically included briefings of the Technical Coordinating Committee (TCC) and Transportation Advisory Committee (TAC) in each region, and the presentation of ITS information to other key transportation groups and officials in the region. The purpose of these presentations and briefings was to promote ITS goals, provide a brief overview of the benefits of ITS, and inform people about the upcoming summit in the region.

Regional Summit. One to four regional summits were held in each of the nine regions. Stakeholders in the regions were invited to these half-day events that featured a presentation of the project background, information regarding the benefits of ITS, and an opportunity for the stakeholders to share and document their key issues.

User Services and Market Packages

The goal of the stakeholder process is to develop a strategic plan of projects that can be implemented that also meet the transportation needs expressed by the stakeholders. Through the development of the NIA, the FHWA has identified 31 user services for urban areas, and 63 market packages that describe projects, and also identifying the information that must be shared between the various components. The process of identifying user services is shown in **Figure 4**.

The overall system architecture can be developed by selecting the appropriate user services and market packages. Grouping these packages together produces the overall system architecture and shows the data that must pass between elements and agencies. The user services generate categories of projects, such as traveler information. The packages are more specific types of projects.

There are seven critical program areas within ITS. Those seven programs are:

Traveler Safety and Security - Technologies use a in-vehicle sensors and information systems to alert drivers to hazardous conditions and dangers. This program features wide-area information dissemination of site-specific advisories and warnings.

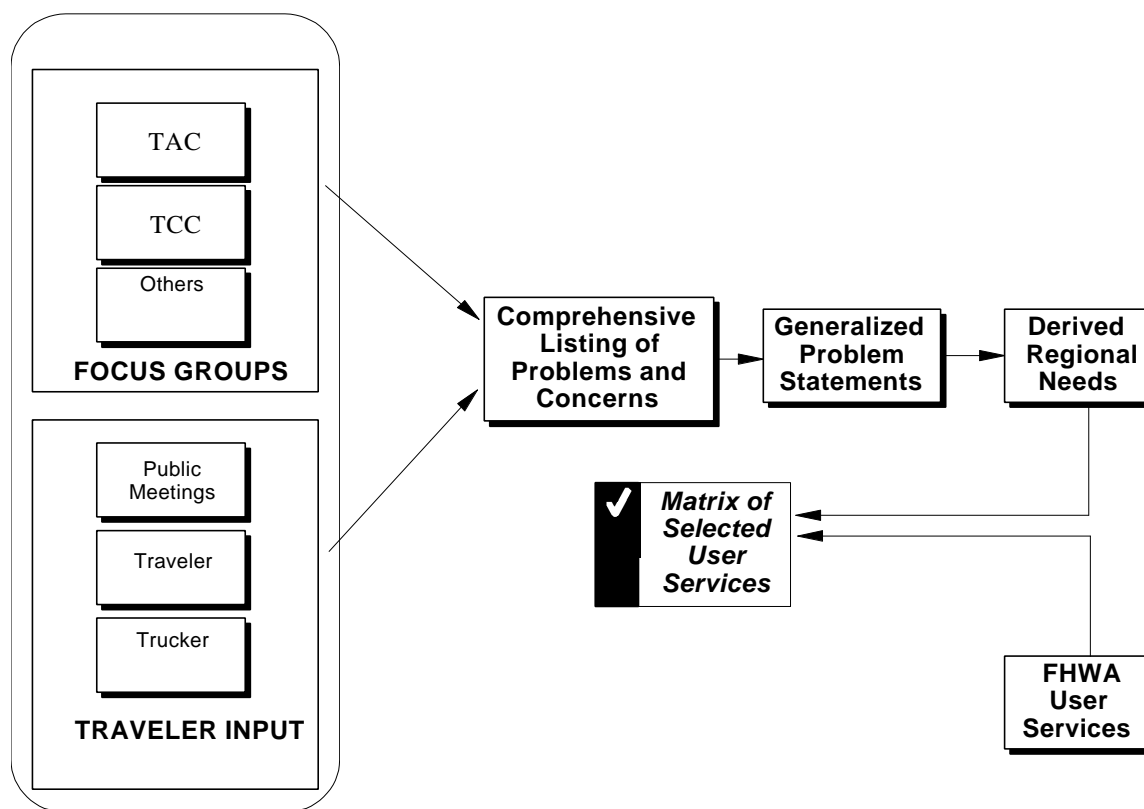


Figure 4. Identification of Needs and User Services

Tourism and Travel Information Services - Use in-vehicle navigation and roadside communication systems to provide information to travelers who are unfamiliar with the local areas. These services can be provided at specific locations, en-route, or prior to departure.

Public Traveler/Mobility Services - Improves the efficiency of transit services and their accessibility to residents. These services include better scheduling, improved dispatching, Smart Card readers and payment, and computerized ride-sharing systems.

Emergency Services - Use satellites and advanced communications systems to automatically notify the nearest police, fire, or rescue squad in case of collision or other emergency.

Fleet Operations and Management - Improves the efficiency of fleets of vehicles that operate in urban areas, such as utility readers, package delivery services, mail carriers, law enforcement, etc.

CVO - Satellites, computers, and communications systems manage the movement and logistics of commercial vehicles, and locate and track these vehicles during emergencies.

Infrastructure Operations and Maintenance - Improve the ability of highway workers to maintain and operate urban streets more efficiently. These services include severe weather information and immediate detection and alerting the public to dangers such as the presence of work zone crews.

The NIA lists potential ITS market packages to go with these critical program areas. There currently are 63 market packages in the NIA. **Table 1** lists specific market packages that are applicable to most urban regions and may be applicable in the Asheville Region.

The following example illustrates the benefit of this categorization of market packages. The Regional ITS Summit in the Asheville Region identified the issue of providing traveler information by using kiosks. Various types of two-way communications devices were discussed. These transportation information needs were translated into consolidated information that can be provided to the traveling public with two-way capability. Affected ITS critical program areas would include Tourism and Traveler Information as the major component. Within the Tourism and Traveler Information program area, for example, the following market packages were determined to be applicable:

- Broadcast traveler information
- Interactive traveler information
- Yellow pages and reservations
- Autonomous route guidance
- In-vehicle signing

Traffic information dissemination is another market package that is listed in the NIA as belonging in the infrastructure operations and maintenance area, and this market package also is applicable.

By identifying these five as the primary market packages to meet the needs of metro area travelers, the specific data and communication issues can be identified at an early step. The way that subsystems, technology packages, and market packages fit together in a regional ATIS architecture is shown in **Figure 5**.

The interactive traveler information market package exemplifies the market packages that are applicable to urban regional ITS architectures. This market package provides tailored information in response to traveler requests. Users can request and obtain current information on traffic conditions, traveler services, and parking. A range of two-way, wide-area wireless, and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route including plain old telephone (POT) service; traveler information kiosks in welcome centers, truck stops, etc.; Personal Digital Assistant (PDA); home computers; and a variety of in-vehicle devices.

The successful deployment of this market package relies on the availability of real-time transportation data from the Transportation Management System (TMS) or Transportation Regional Management System (TRMS). This market package also requires an entity (or entities) to process and disseminate the information - the information service provider (ISP). The ISP interfaces with the remote traveler support subsystem and personal information access subsystem to receive individual travelers' requests and respond with information. **Figure 6** shows the Interactive Traveler Information market package. Note that the information flows to the vehicle are displayed with dotted lines. This interface will probably not be available until the mid- or long-term timeframe (depending upon how quickly services become available nationally).

Table 1. Probable ITS Market Packages Based on Typical Needs in Urban Areas

| Critical Program Areas | Specific ITS Market Packages (Taken from the <i>ITS National Program Plan and National Architecture</i> , as amended) |
|---|---|
| Traveler Safety and Security | Traveler Security Intersection Safety Warning Intersection Collision Avoidance |
| Tourism and Travel Information | Broadcast Traveler Information Interactive Traveler Information Yellow Pages and Reservations Autonomous Route Guidance In-vehicle signing |
| Public Traveler/Mobility Services | Multimodal Traveler Information Demand Response Transit Operations Transit Passenger and Fare Management Transit Security Transit Maintenance |
| CVO | CVO Fleet Administration /Coordination Freight Administration Fleet Administration Electronic Clearance HAZMAT Management |
| Emergency Services | Emergency Response Emergency Routing MayDay Support |
| Infrastructure Operations and Maintenance | Incident Management Traffic Information Dissemination Probe Surveillance Traffic Forecast and Demand Management Advanced Railroad Grade Crossing Road Weather Information System |
| Other | ITS Planning |

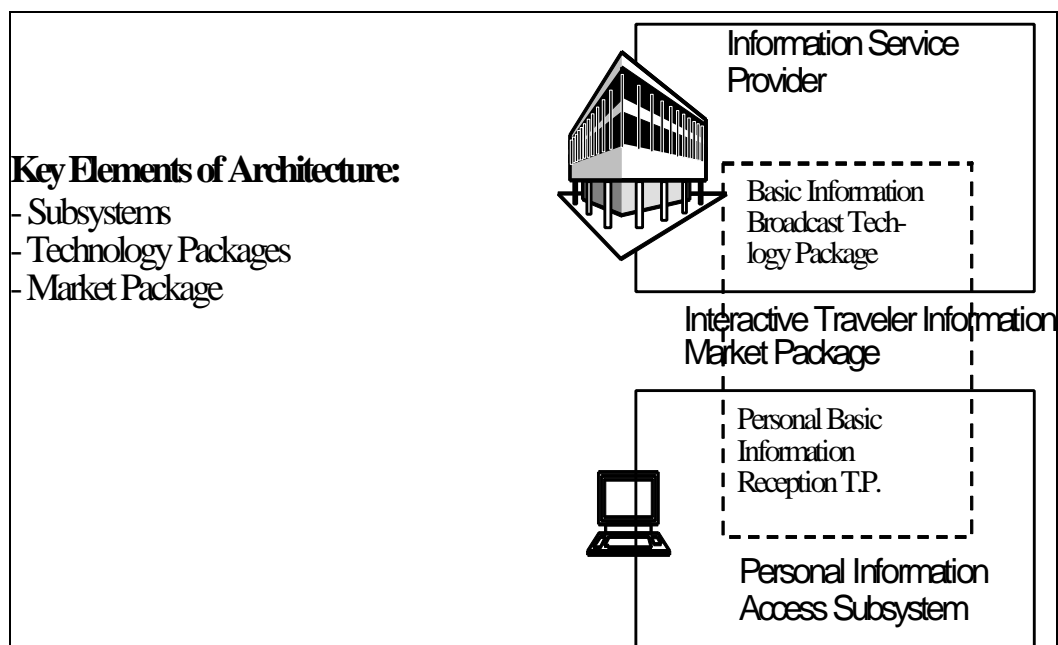


Figure 5. Relationship of Market Packages, Technology Packages, and Subsystems

The user services and market packages are traceable directly to the architecture definition. Once a market package is selected for implementation, the required subsystems, equipment packages, and interface requirements may be identified. The benefit of this approach is that it allows the agency or organization deploying the technology to first consider deployment options and later concentrate on those pieces of the architecture necessary to support the selected deployment.

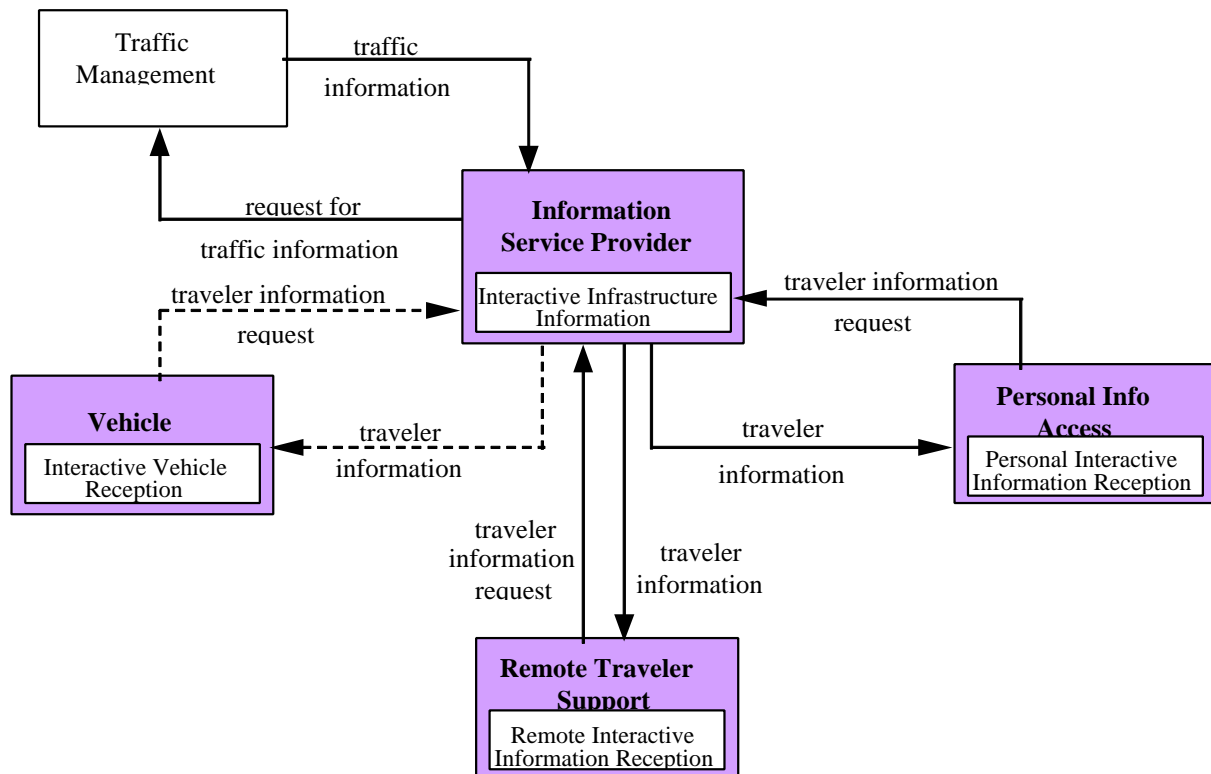


Figure 6. Interactive Traveler Information Market Package

Regional Overview

The Asheville Region encompasses Buncombe, Henderson, Madison, Yancey, Mitchell, McDowell, Polk, Rutherford and Cleveland Counties. It has a population of greater than 250,000 people, and includes the area surrounding the cities of Asheville, and Hendersonville. Other cities in the Asheville Region include: Black Mountain, Fairview, Weaverville, Woodfin. The major cities, roadways, and other key features of the Asheville Region are shown in **Table 2**.

Table 2. Asheville Region General Information

| | NCDOT | | | | |
|-----------|----------|------------|----------------|-----------------------------|-----------------------|
| County | Division | Population | Major Cities | Major Roads | Military/Universities |
| Buncombe | 13 | 197,000 | Asheville | I-26, I-40 | UNC-Asheville |
| | | | Black Mountain | US 19, US 70, US 74 | Warren Wilson College |
| | | | Fairview | NC 9, NC 63, NC 191, NC 197 | Montreat College |
| | | | Weaverville | NC 251 | |
| | | | Woodfin | | |
| Henderson | 14 | 28,000 | Hendersonville | I-26 | |
| | | | | US 25, US 64, US 176 | |
| | | | | NC 9, NC 146, NC 191 | |

Overview of ITS in the Region

Although relatively new, many ITS deployments are either fully functional, in construction, or in the planning stages throughout the State. Included in these deployments is a coordinated signal system.

Regional Strategic Deployment Plan Process

Meetings

To prepare and plan for the Asheville Regional summit, a planning meeting was held on December 9, 1999. The minutes for this meeting are included in the Appendix. The TAC meeting provided an overview of the entire project as well as the process to be followed for the regional and statewide plans. The meeting included a discussion of project-specific issues, including:

- The perception of ITS in the Region
- Comments on the proposed process
- Identification of the stakeholders

The discussion helped to identify some of the key aspects of the project that needed to be carried forward throughout the process.

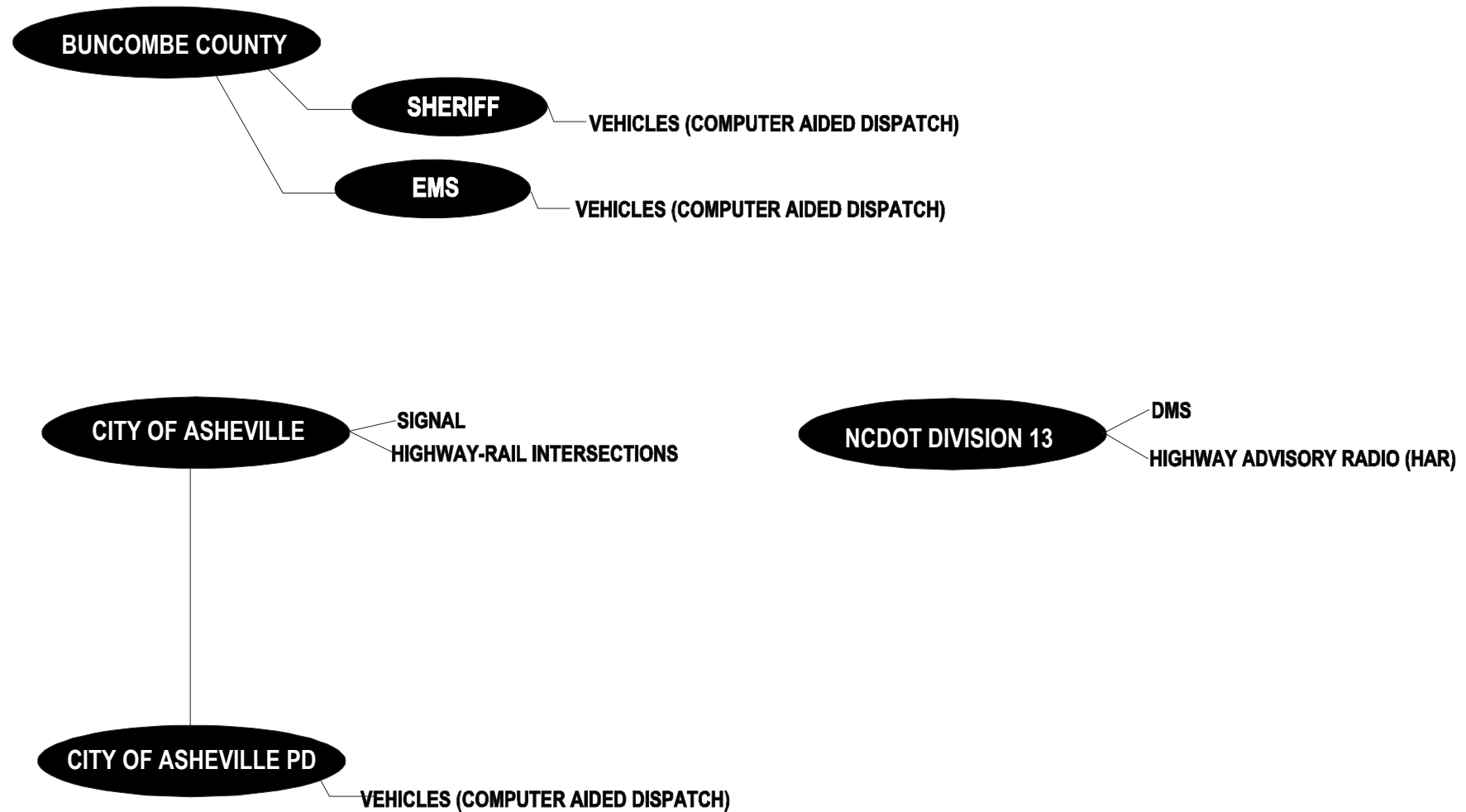


FIGURE 7 SCHEMATIC REPRESENTATION OF ASHEVILLE REGION ITS ELEMENTS

Summits

Following the TAC meeting a regional summit meeting was held on March 8, 2000.

The summit gave people from many backgrounds, along with transportation-related professionals, the opportunity both to learn more about ITS and to provide input on the specific needs that can be met using ITS products and technologies. Attendees included mayors, city and state traffic engineers, emergency services, schools, and major employers. Members of the news media also were invited. The minutes from this meeting are provided in the Appendix.

Identification of Transportation Needs or Issues

As a result of the meetings, summits, and breakout groups, four key program areas for the Asheville Region were identified:

Tourist Information
Traveler Information
Weather Information
Road Condition/Construction Information

The key transportation issues were identified based on the discussions of the various groups in the break-out session in the regional Summit. Thirty specific issues were identified in the transportation summits. Of the 30 needs, the following five groupings or sub-categories were identified:

Traveler Information

- Lack of pre-trip tourist information
- Highway Advisory Radio (HAR) is not as effective as it could/should be
- Lack of real time traffic information
- Lack of traveler information – via message signs
- No IMAP unit
- Need IMAP Coordinator
- Need up-to-date HAZMAT information
- Real-time weather information, fog detection, and early warning of reduced visibility
- Information on construction, weather, road conditions, rock slides
- Traveler Information Kiosks (@ Rest areas, hotels, Super K, malls, other locations)
- FCC *211 – cellular telephone – information

Freeway Management

- Lack of route guidance for getting around incidents
- Special event traffic management

Inter-jurisdictional Coordination

- Lack of coordination among local agencies
- Need for increased interagency communication
- Better coordination with Asheville Police Department
- Communication links to TNDOT

CVO

- Truckers should have access to traffic information
- Need better CV weight detection and enforcement
- Trucking and grade, truck lane restrictions signing
- Communications including e-mail to CVO providers, dispatchers, trucks in transit, etc.
- Improve commercial vehicle weight operations and law enforcement

Transit

- Need better integration of transit with other modes (school, commuter, park and ride)
- Public transportation, pedestrian to bus, rail to bus, bike to bus needs
- Develop flexible system that provides access to major attractions (Biltmore Estates, Blue Ridge Parkway)
- Creation of intermodal complex (hub)
- Expand growth of transit to malls
- Implement/expand carpool/vanpool
- Coordination of demand responsive trips between counties
- Need rail right of ways

Several needs that were not identified in the Asheville Regional summit were identified in one or more of the previous urban regional meetings. Some of these needs, and some identified in the urban summits, have been identified as linkages to statewide or “extra-regional” needs.

This information was grouped into market packages to develop a regional ITS architecture. This process is described in detail later in this report.

Regional Strategic Plan

The basic premise for this ITS Strategic Deployment Plan is to identify the transportation problems and needs in North Carolina and to select ITS technologies that can be used to address these needs. The ITS technology selection process begins with identifying appropriate ITS user services. User services represent functions performed by ITS technologies and organizations for the direct benefit of the traveling public.

The National ITS program plan defines the term *users* as: “a wide range of individuals and organizations including drivers, travelers, service providers, and transportation policy makers.” The NIA currently defines 31 user services. In addition the USDOT has developed the Advanced Rural Transportation System (ARTS) program to respond to more rural ITS needs. The ARTS program has identified an additional six users services for rural areas that are in the process of being approved for inclusion in the NIA. **Table 3** lists all 37 user services listed in the NIA and ARTS, and also provides a brief definition of each.

Table 3. ITS User Services. (*ARTS User Service.)

| | | |
|-----|--|---|
| 1 | Pre-Trip Travel Information | <i>Provides information for selecting the best transportation mode, departure time, and route.</i> |
| 2 | En-Route Driver Information | <i>Provides advisories and in-vehicle signing for convenience and safety.</i> |
| 3 | Route Guidance | <i>Provides travelers with instructions on how to reach their destinations.</i> |
| 4 | Ride Matching and Reservation | <i>Makes ride sharing easier and more convenient.</i> |
| 5 | Traveler Services Information | <i>Provides a business directory, or "yellow pages," of service information.</i> |
| 6 | Traffic Control | <i>Manages the movement of traffic on streets and highways.</i> |
| 7 | Incident Management | <i>Helps quickly identify incidents and implement a response.</i> |
| 8 | Demand Management and Operations | <i>Supports policies to mitigate the environmental/social impacts of traffic.</i> |
| 9 | Emissions Testing and Mitigation | <i>Provides information for monitoring air quality.</i> |
| 10 | Highway Rail Intersection | <i>Provides improvements to automated crossing control systems.</i> |
| 11 | Public Transportation Management | <i>Automates operations, planning, and management of public transit.</i> |
| 12 | En-Route Transit Information | <i>Provides information on public transportation after the trips begins.</i> |
| 13 | Personalized Public Transit | <i>Provides flexibly routed transit to offer more convenient service.</i> |
| 14 | Public Travel Security | <i>Creates a secure environment for transportation patrons and operators.</i> |
| 15 | Electronic Payment Services | <i>Allows travelers to pay for transportation services electronically.</i> |
| 16 | CVO Electronic Clearance | <i>Facilitates domestic and international border clearance.</i> |
| 17 | Automated Roadside Safety Inspection | <i>Facilitates roadside inspections.</i> |
| 18 | On-Board Safety Monitoring | <i>Senses the safety status of a commercial vehicle, cargo, and driver.</i> |
| 19 | CVO Administrative Processes | <i>Provides electronic purchasing of credentials, etc.</i> |
| 20 | Hazardous Material Incident Response | <i>Provides immediate description of hazardous materials.</i> |
| 21 | Commercial Fleet Management | <i>Provides communication between drivers, dispatchers, and providers.</i> |
| 22 | Emergency Notification and Personal Security | <i>Provides immediate notification of an incident and immediate request for assistance.</i> |
| 23 | Emergency Vehicle Management | <i>Reduces incident response time for emergency vehicles.</i> |
| 24 | Longitudinal Collision Avoidance | <i>Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.</i> |
| 25 | Lateral Collision Avoidance | <i>Helps prevent collisions when vehicles leave their lane of travel.</i> |
| 26 | Intersection Collision Avoidance | <i>Helps prevent collisions at intersections.</i> |
| 27 | Vision Enhancement for Crash Avoidance | <i>Improves the driver's ability to see the roadway and objects that are on or along the roadway.</i> |
| 28 | Safety Readiness | <i>Provides warnings about the condition of the driver, vehicle, and roadway.</i> |
| 29 | Pre-Crash Restraint Deployment | <i>Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.</i> |
| 30 | Automated Vehicle Operation | <i>Provides a fully automated hands-off operating environment.</i> |
| 31 | Archived Data User Service | <i>Provides for automated historic data archiving and sharing.</i> |
| 32* | Portable Traffic Management | <i>Traffic surveillance and control that is flexibly and speedily deployable, for highway and traffic conditions that are accidental, sporadic or seasonal.</i> |
| 33* | Road Maintenance and Management | <i>The efficient maintenance and rapid repair of roads.</i> |
| 34* | Seasonal Harvesting | <i>The coordination of intermodal transportation resources and agricultural production.</i> |
| 35* | Economic Development (Business Viability) | <i>The improvement of transportation efficiency, the reduction of adverse transportation impacts.</i> |
| 36* | Economic Development (Tourism) | <i>The dissemination of information that promotes compatible enjoyment of parks other tourist sites, and services to tourists.</i> |
| 37* | ITS Planning and Marketing Data | <i>The collection and processing of information derived from the operation and evaluation of ITS.</i> |

Regional Plan Development Methodology

The objective of this task was to determine, based on stakeholder input, which of the 37 ITS user services need to be implemented in the Asheville Region and how to phase their implementation (i.e., in the short- or long-term timeframes). Since delivering a user service takes more than just one piece of equipment, the ITS architecture groups equipment into market packages.

While user services help us define what is needed, their corresponding market packages describe how to provide those services. Each market package consists of a group of elements (equipment packages) that work together to deliver a particular user service. To identify the specific technology groups that will be needed to provide the selected user services, market packages corresponding to each selected user service were identified in this task.

The activities of this task were divided into three steps aimed at producing a well-defined, integrated user service plan, as follows:

- Identification and prioritization of applicable user services based on previously identified transportation needs of the region and development of user services deployment timeframes
- Development of specific user objectives and performance criteria
- Selection of market packages

The following section describes the above steps in more detail. The remainder of this section of the report provides a complete description of each activity associated with these steps.

The first step in this task focused on identifying the user services appropriate for North Carolina based on previously identified regional needs. First, the original statements of problems and concerns gathered through stakeholder meetings in each of the summits were assembled into a comprehensive list. Next, this list of original, raw statements was reduced and refined through grouping of similar statements into concise need statements. This step also eliminated those problem statements not directly related to transportation issues that could be related to ITS. Lastly, these needs were placed in a separate category of non-ITS related needs. Lastly these concise need statements were matched with appropriate ITS user services.

The Asheville Region's transportation-related needs, identified in the previous section, were matched, or mapped, with the 37 applicable ITS user services, resulting in a preliminary set of user services to be deployed specifically in the Asheville Region. Several overlapping needs that were identified in the two contiguous urban regions (Triangle, Triad and Metrolina) that need to be carried over to the Asheville Region.

These user services were prioritized based on the relative ranking of each related need. The regional team provided the needs ranking, in terms of importance, during regional team meetings. Based on the priority ranking of each user service and using the common objectives and overlapping functionality of the user services, preliminary short- and long-term deployment timeframes for groups of user services were identified

In the next step, system objectives were defined for each identified user service. A system objective identifies the improvements in the system that can be expected to occur as a result of a successful implementation of a user service. To judge the degree of success of the implementation of the user services, including the effectiveness of the deployed service or technology in solving the original problem, a set of performance criteria was developed.

Finally, to begin defining the physical ITS architecture for each region and for the state, market packages corresponding to the selected user services were identified. The 63 currently defined ITS market packages are an important building block of the statewide ITS architecture definition process and represent specific portions of the architecture that may be required to satisfy the needs identified by North Carolina stakeholders.

Input Mapping to User Services

The transportation needs for the Asheville Region, as discussed in the previous section, were mapped to the user services categories in the NIA. The user services mapping is shown in **Table 4**.

Ranking of Identified Needs

The prioritization of user services was based on the relative ranking of each of the 30 needs identified by the stakeholders. The Asheville Region's transportation stakeholders, ranked the needs during the first regional team meeting.

The assignment of the need rankings (shown in **Table 5**) to the matched user services was accomplished by summing the point scores of all the needs corresponding to each matched user service as shown in **Table 4**. **Table 5** shows the ranking of these needs by stakeholders involved in the ITS project from the Asheville Region.

The score for each user service was expressed in percentage of the total score (equal to the sum of scores for all user services), and plotted on a bar chart. **Figure 8** shows the resulting ranking of the user services receiving points.

The user services in **Figure 8** were identified as most likely to achieve Strategic Planning success in the Asheville region. This selection was not intended to exclude other user services as needed in specific areas. The list of user services does, however, represent recommendations of regional services on which the remainder of this strategic plan was based.

Table 4. Matching User Needs to User Services

[illegible]

Table 5. Coalition Ranking of Identified Needs (by Score).

| ID# | Needs | Ranking |
|-----|--|---------|
| 10 | Traveler Information Kiosks (@ Rest areas, hotels, Super K, malls, other locations) | 1 |
| 3 | Lack of real time traffic information | 2 |
| 4 | Lack of traveler information - Via Message Signs | 3 |
| 1 | Lack of pre-trip tourist information | 4 |
| 8 | Real-time weather information, fog detection, and early warning of reduced visibility | 5 |
| 9 | Information on construction, weather, road conditions, rock slides | 6 |
| 24 | Public transportation, pedestrian to bus, rail to bus, bike to bus needs | 7 |
| 22 | Improve commercial vehicle weight operations and law enforcement | 8 |
| 17 | Communication links to TNDOT | 9 |
| 21 | Communications including e-mail to CVO providers, dispatchers, trucks in transit, etc. | 10 |
| 18 | Truckers should have access to traffic information | 11 |
| 20 | Trucking and grade, truck lane restrictions signing | 12 |
| 19 | Need better CV weight detection and enforcement | 13 |
| 23 | Need better integration of transit with other modes (school, commuter, park & ride) | 14 |
| 25 | Develop flexible system that takes you to major attractions (Biltmore Estates, Blue Ridge Parkway) | 15 |
| 27 | Expand growth of transit to malls | 16 |
| 26 | Creation of intermodal complex (hub) | 17 |
| 2 | Highway Advisory Radio is not as effective as it could/should be | 18 |
| 7 | Need up-to date HAZMAT information | 19 |
| 11 | FCC *211- cellular telephone – information | 20 |
| 12 | Lack of route guidance for getting around incidents | 21 |
| 15 | Need for increased interagency communication | 22 |
| 16 | Better coordination between Asheville Police Department | 23 |
| 14 | Lack of coordination amongst local agencies | 24 |
| 28 | Implement/ expand carpool/ vanpool | 25 |
| 5 | Need IMAP coordinator | 26 |
| 6 | No IMAP Unit | 27 |
| 13 | Special Event Traffic Management | 28 |
| 29 | Coordination of demand responsive trips between counties | 29 |
| 30 | Need rail right of ways | 30 |

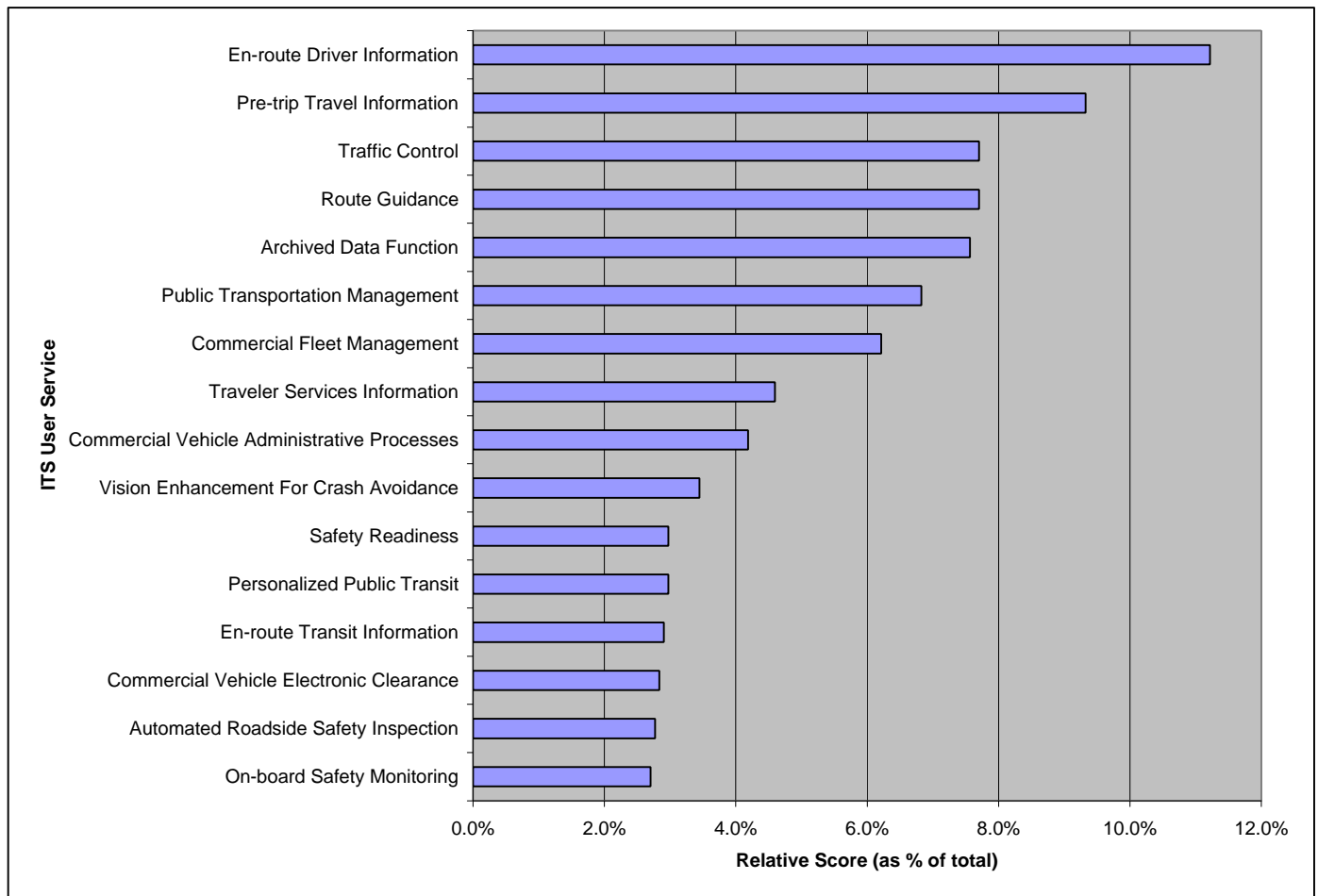


Figure 8. User Services Ranking (based on relative importance of associated needs)

Selection of Market Packages

The NIA defines the purpose of market packages as addressing specific services that might be required by traffic managers, transit operators, travelers, and other ITS stakeholders. The market packages are tightly coupled with the architecture definition and represent the building blocks that can be deployed over time to efficiently achieve high-end ITS services. Several different market packages are defined for each major application area, which provides a palette of services at varying costs.

Market packages also are identified to segregate services that are likely to encounter technical or non-technical challenges from lower risk services. For example, driver warning and vehicle control systems are defined as separate market packages due to the increased technical and non-technical risks associated with systems that dilute the driver's direct control of the vehicle. This approach yields market packages that may be deployed early with low risk. Many of the market packages are incremental so that more advanced packages can be efficiently implemented based on earlier deployment of more basic packages. In short, market packages represent ITS services and implementation options that may be considered by system implementers.

The selection of appropriate market packages is an important step in the ITS strategic planning process. Historically, market packages were introduced in the planning process, after user services that, along with functional requirements, were the last steps in the process before architecture definition. The ITS deployment guidelines have evolved to include additional steps and alternative paths for urban, regional, or Statewide ITS strategic plan developments.

The objective of this task was to identify a set of candidate market packages for potential deployment in the Asheville Region of North Carolina. The NIA provides a matrix connecting the 37 user services and the 63 market packages. This matrix allows market packages and user services to be tracked to identify specific projects and their coverage of elements in the NIA.

Table 6 illustrates the matching of the user services previously identified to the market packages. The selected market packages corresponding to the transportation needs identified by the stakeholders are indicated with a "YES". Linkages that exist, but are not applicable to the identified Asheville Region stakeholder needs are indicated with a "NO".

Note that 24 of the possible 63 market packages were identified as potentially deployable in the Asheville Region. This is due to the fact that deployment of several of the identified user services will require portions of numerous market packages. For example, the traffic control user service is matched with 5 market packages. While this selection may at first sight appear too broad and indiscriminate, one must keep in mind that these market packages represent sets of specific technology applications, called equipment packages, that need not all be implemented to deploy a given user service.

Table 6. Market Packages Mapped to User Services Relationships

[illegible]

Asheville Region ITS Architecture

The ITS architecture is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. This chapter describes the process of developing the Asheville Region architecture.

The national ITS plan originally defined a series of short-, medium-and long-term deployment timeframes for ITS. Several years have passed since this timeframe was developed, and the initial goal was to match schedules with the reauthorization of ISTEA. This schedule reflected FHWA's desire to implement, as quickly as possible, visible and effective ITS projects that would stimulate public support for additional funding for future deployment programs.

For the purposes of this regional ITS plan, and taking into account that the ISTEA reauthorization occurred when TEA-21 was passed in 1998, the deployment timeframes for a regional implementation of selected user services are based on anticipated funding, need, and lead-time for the typical planning, design, and implementation schedules for transportation projects.

The following deployment timeframes have been identified for the Asheville regional ITS plan, consistent with the other regional plans in North Carolina:

| | |
|------------|-------------------------------|
| Short-Term | through fiscal year 2006 |
| Long-Term | 2006 through fiscal year 2011 |

General Description of ITS Architecture

The ITS architecture is comprised of two technical layers: a transportation layer and a communications layer. The transportation layer involves the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The communications layer provides for the transfer of information between the transportation layer elements. The transportation and communication layers together form the *architecture framework* that coordinates overall system operation by defining interfaces between equipment that may be deployed by different procuring and operating sectors.

The transportation layer involves 19 interconnected subsystems as shown in **Figure 9**. A complete description of each subsystem, along with its architecture diagram, is provided in the national architecture documents.

In general, the communication layer consists of two components: one wireless and one wireline. The transportation layer is supported by one or both of these components. The wireline portion of the network can be manifested in many different ways, and most of them are implementation dependent.

A simplified view of the communications interface is provided in the Very Top Level Architecture Interconnect Diagram in **Figure 9**.

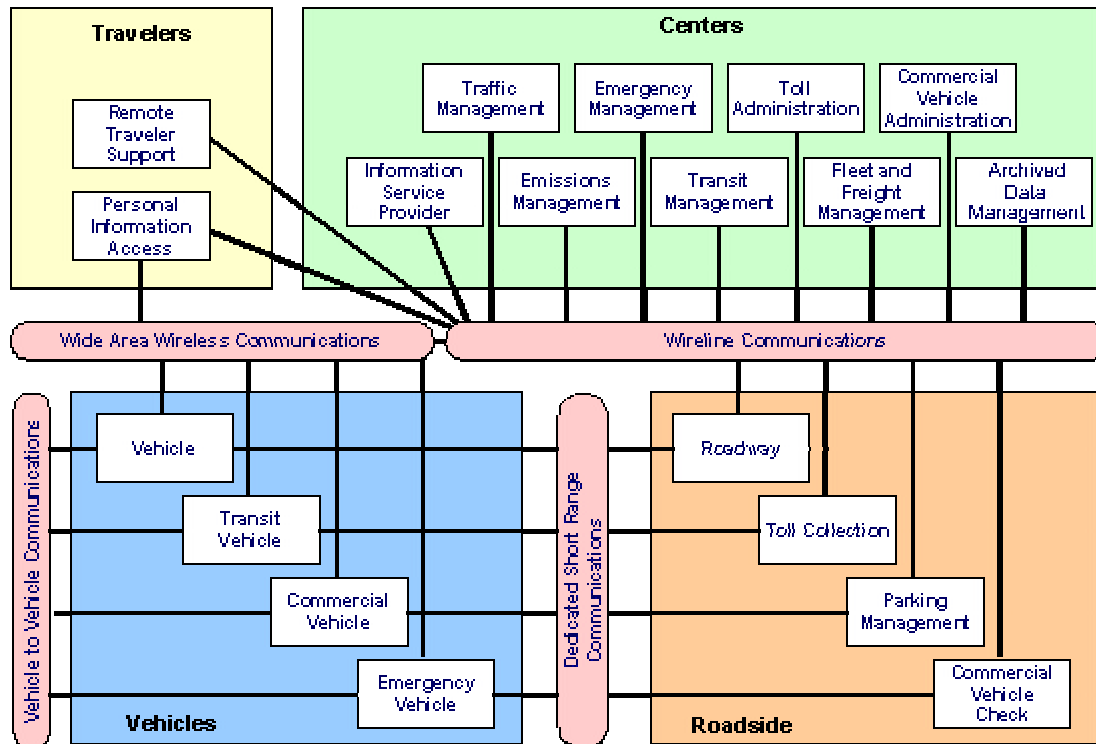


Figure 9. Very Top Level Architecture Interconnect Diagram

Another element of the architecture is the institutional layer, which documents the policies, funding incentives, working arrangements, and jurisdictional structure that supports the transportation and communication layers of the architecture. The institutional layer describes who is responsible for deploying of the specific market packages and individual ITS projects and programs. It also identifies opportunities for public-public and public-private partnerships that will be necessary for successful deployment and/or operations and maintenance.

Recommended ITS Physical Architecture

The regional team facilitated market package selection. Each member of the regional team was given an opportunity to identify candidate technologies, projects and concepts to meet the transportation needs identified. Based on this input, market packages for the selected user services were identified, as was the priority in terms of short-and long-term projects. The resulting market package deployment within each of the applicable user services is summarized in **Table 7**.

S – Short-term Project/Market Package
L – Long-term Project/Market Package

Table 7. Market Package Deployment, by Timeframe

[illegible]

Recommended Projects and Technologies

This section summarizes the technology recommendations that support the short-and long-term deployment of ITS in the Asheville Region. These are the same deployment horizons used elsewhere in this report. The following list summarizes these technologies:

Short-Term (2000 - 2006) Technologies

1. IMAP Management Plan
2. Highway Fog Warning System
3. Automatic Vehicle Location (AVL) for Transit
4. HAR
5. Website

Long-Term (2006 - 2011) Technologies

1. Transit System Expansion
2. DMS
3. Kiosks
4. ATIS Enhancements
5. 511 Traveler Information

Technologies Especially Applicable to Urban Areas

Traveler Information Kiosks – Kiosks provide users with free access at rest areas, welcome centers, etc. to a wide range of information available from state transportation agencies, tourist destinations and organizations, local governments, and downloaded information from the Web. In addition, users can check their e-mail, surf the Web, or use a search engine for a charge. Three types of kiosks have been developed for these applications: sit-down, stand-up, or stand-alone countertop unit. Some of these units are designed to supplement traveler counselors available at most state welcome centers (Source: Arizona DOT).

World Wide Web – The Web provides access to a universe of information, some of which (weather, road closures, etc.) can be downloaded from other sites. Applications are for users prior to departure, although en-route information can be provided at kiosks in welcome centers.

In-vehicle Automatic Vehicle Location (AVL) System – Integrated units featuring a global positioning satellites (GPS) receiver, cellular digital packet data (CDPD) modem, processor, keypad, display and sensor interface are available. Some units are designed to interface to vehicle sensors and controls such as road temperature, material spreaders via standard RS-232/RS-485 interface, and can detect plow or sweeper up/down status. Functions include operator log-on, vehicle position and transmitting, emergency alarms, two-way messaging, and sensor data collection and storage. (Source: Orbital Sciences Corp., Germantown, Maryland.)

Vehicle Tracking and Information System Software - These systems are integrated with the in-vehicle device referenced above, and include the mapping, messaging, reporting, playback and vehicle information functions. Reporting takes place through an open database connectivity (ODBC) compliant database, and information includes such data as total operating miles, deadhead miles, material spread

(maintenance vehicles), road temperatures, etc. (Source: Orbital Sciences Corp., Germantown, Maryland.)

Lateral warning and guidance system. This magnetic tape helps snow plow operators during difficult winter weather conditions. Magnetic tape is grooved into the pavement, typically along the center lane markings or along the edge line. Magnetic media and pliant polymer pavement markings are two technologies that work together in this system. This system is adapted for all-weather, all-light condition performance. (Source: 3M Safety and Security Systems Division, St. Paul, Minnesota.)

Traffic Sensing System – Magneto-inductive sensors are installed in the pavement and transduce small magnetic charges into inductive charges. These charges permit data collection for monitoring traffic. These systems consist of sensors, sensing electronics, cabling, and installation components. They support traffic data collection and storage to monitor speed, number of vehicles by classification, lane occupancy, and vehicle length. (Source: 3M Safety and Security Systems Division.)

Surveillance and Delay Advisory System (SDAS) - The SDAS consists of three data collection technologies: WIM, video-based sensing, and spot speed measurements. The system gathers data from a construction zone (the area around a special venue such as a tourist destination), computes travel times and delays through the zone of interest, and transmits delay messages to motorists traveling through the zone. (Source: Office of Safety Research and Development, FHWA, McLean, Virginia.)

DMS - Special attention for use of DMS in urban areas include traffic congestion advisories, tourist information, and various events - such as duration, size, and severity.

Description of Strategic Plan Projects

This Asheville Regional ITS Strategic Plan has identified the needs of the Asheville Region's transportation stakeholders, and has matched them, where possible, to one or more ITS market packages, each representing an ITS solution. Of the 63 market packages currently defined in the NIA, 24 were identified as suitable for deployment in the region. By identifying the desired implementation horizon for each of the 24 selected market packages, technology deployment phasing was developed. The recommended ITS solutions were once again cross-checked against the identified user needs, resulting in a more complete set of recommendations.

This section lists the technologies that should be deployed to achieve the desired functionality of each selected market package. The project title, description, and estimated cost of each deployment is listed. In addition, the schematic diagram of the existing, planned, and programmed ITS deployments in the region has been modified to show the proposed short-and long-term proposed deployments. This modified schematic is shown in **Figure 10**.

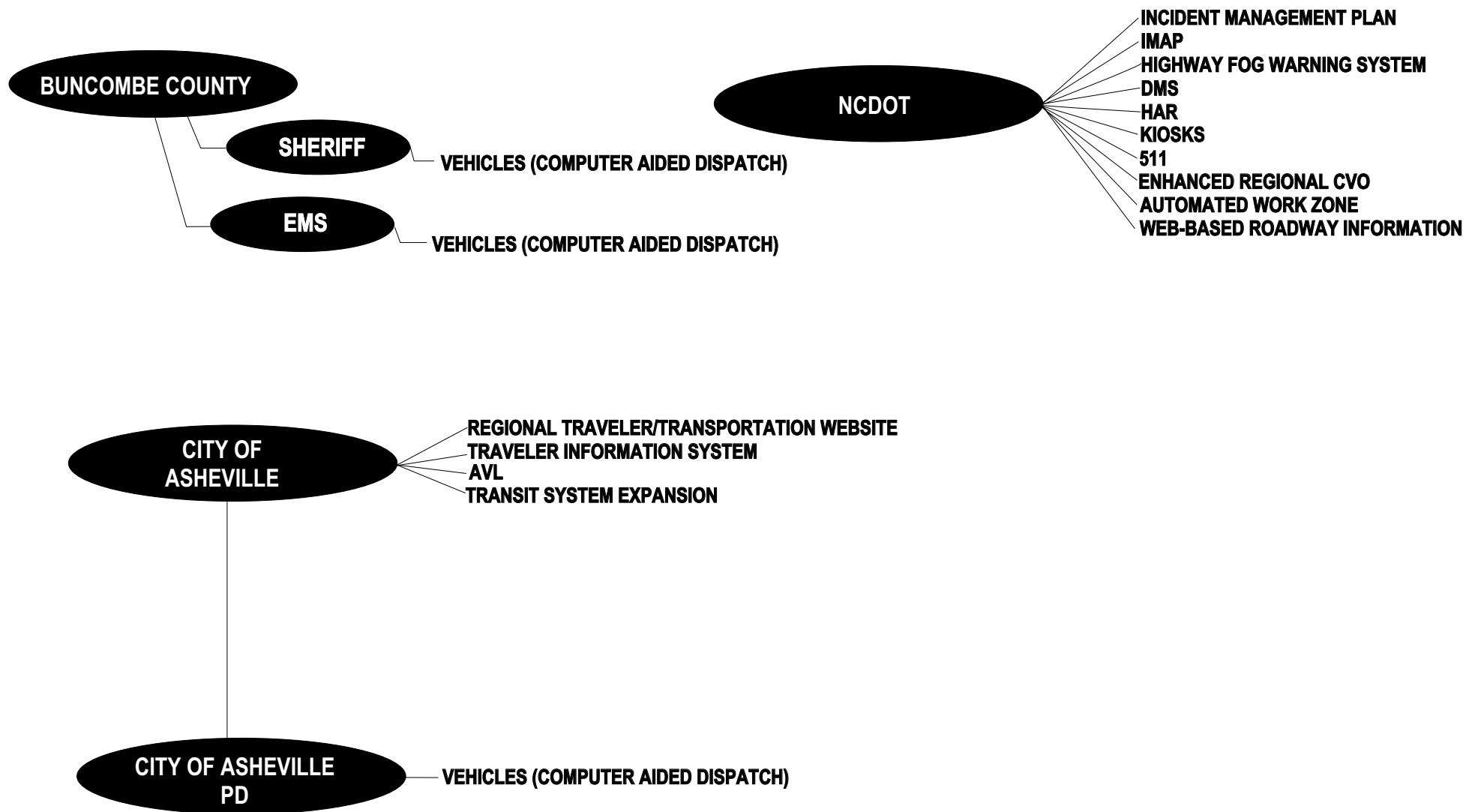


FIGURE 10 SHORT AND LONG TERM ITS DEPLOYMENT IN THE ASHEVILLE REGION

Short-Term Projects

The following projects are recommended for short-term deployment in the Asheville Region. The projects are grouped according to systems. All costs shown are assuming year 2001 dollars.

Freeway/Incident/Event Management

Incident management plan. NCDOT and the interagency team in the Asheville Region will develop a regional incident management plan. The purpose of this plan is to prepare a predefined set of responses to major incidents that is agreed upon by all of the agencies in the region. Coordination with the states of Tennessee, Georgia, and South Carolina is important due to their proximity to the Asheville Region.

IMAP in Asheville. The IMAP program has been very successful throughout the state of North Carolina in the regions where it has been established. This program will be expanded into the Asheville Region by providing two new vehicles and drivers. This project is anticipated to cost \$400,000 for the initial capital investment, with on-going costs of approximately \$300,000 per year for Operations and Maintenance.

Highway fog warning system. The Asheville region is prone to fog due to its mountainous terrain. One device that has been developed to detect and measure the light scattered in a forward direction by moisture in the air is a nephelometer. These devices are smaller and lighter than previous models as currently developed, and are spaced between 200 and 700 feet to detect both patchy as well as dense fog. The sensor unit consists of an optical scanner, electronics, and software for communication to a host computer. The sensor is designed to provide (1) accurate fog density measurement, (2) low maintenance requirements, and (3) selected output format. Communication can be either cable, fiber, wireline, cellular, or RF. These sensors will be installed along highways in the Asheville Region, and the information collected can be disseminated to the public via several sources, including DMS, HAR, web sites, and traveler information telephone lines. The anticipated cost of this project is \$600,000.

Transit

Bus AVL system. The buses in the region will be outfitted with AVL systems to permit tracking and enhanced data collection. In addition, an automatic vehicle identification (AVI) system will be implemented to work with the AVL for a more comprehensive tracking and scheduling system. Finally, these two systems will be tied into on-bus systems that permit automatic passenger counters. The anticipated cost to outfit the buses with this system and provide central software in the Asheville Region is \$250,000.

Traveler Information

DMS. There is a need for motorists on major highways and arterials to have frequently updated information regarding road construction, incidents, and road conditions. In a mountainous region such as Asheville, signs also can be employed to display weather-related information such as fog advisories, and warnings to truckers about steep mountain grades. Signs will be installed at 2 sites in the Asheville Region. The anticipated cost for these improvements is \$400,000.

Additional HAR sites. NCDOT will expand the existing HAR system by adding additional HAR sites on both AM and FM radio. These sites will permit a focused response to traffic incidents and issues by alerting motorists to their existence and detailing the appropriate response. These additional HAR's are estimated to cost a total of \$120,000.

Regional traveler/transportation website. NCDOT will develop a website or set of pages at an existing website to provide static travel information. This information may include transit schedules, fares and routes, published road closures, weather, traffic policies, major generator and special event information, rideshare matching information, and links to the MPO, other city and NCDOT websites. This project is anticipated to cost \$50,000 beyond the development costs being borne internally by NCDOT for various ITS web development projects.

Traveler information system. A clearinghouse will be established to store real-time data for traveler information. This system will include data from system detectors, intersections, detector stations, posted incident reports, IMAP incident reports, HAZMAT, and real-time bus schedule information. This information will also be accessible from a central location, whether it is stored locally or remotely. The development of this clearinghouse will be used in kiosks and websites, with the development geared for long-term projects, such as a voice activated telephone system. The anticipated cost to develop this clearinghouse is \$100,000.

Web-based roadway information. As mentioned previously, NCDOT is in the process of developing a web-based real-time regional roadway information system to inform motorists of short-term and long-term road closures. This project will all be done internally to NCDOT, so all of the costs are internal to NCDOT.

CVO

CVISN (Commercial Vehicle Information Systems and Networks). CVISN is the use of ITS information system elements, which support CVO (CVO). This includes a network of information systems owned and operated by governments, carriers, and other stakeholders. The goal of the CVISN process is to use information technologies and networks to transfer credentials concerning commercial vehicles to reduce the time and energy costs typically associated with this process. NCDOT has been actively working to implement CVISN statewide. This includes enforcement and electronic credentials. Some of the projects that are currently underway within the CVISN and ITS/CVO programs include:

Web credentials. NCDOT is in the process of preparing electronic credentials on the web for commercial vehicle operators. A portion of the site is already operational, however the electronic credentials section is still under development. This project is being done internally by NCDOT so no development costs are included here.

Truck presence detection. NCDOT is presently implementing an automated system in the Charlotte area to identify those trucks using alternate routes to bypass weigh and inspection stations.

Mobile inspection. NCDOT and the Department of Revenue are deploying a fleet of vehicles that can check credentials and perform truck inspections remotely throughout the Charlotte area. This fleet, called Wolf Packs, will be used to identify non-compliant trucks and trucks that are using alternate routes to avoid weigh and inspection stations.

Safety

Automated work zones. The NCDOT is in the process of purchasing equipment that provides worker safety in work zones. This equipment consists of standard off-the-shelf packages that feature portable speed and classification detection, speed warning signs, communication (via cellular telephone or radio) to alert police of speeders in a work zone, and, possibly, automatic enforcement measures.

Long-Term Projects

The following projects are recommended for long-term deployment in the Asheville Region. The projects are grouped according to systems.

Transit

Transit system expansion. There is a need to expand the transit system to reach major attractions such as malls and the Biltmore House, and also to improve route planning through advanced travel demand models. Increased integration of transit with other travel modes could be accomplished through an intermodal hub, which also provides access to real-time transit information.

Traveler Information

DMS. The long-term project involves installation of six additional in the Asheville region to provide motorists with important information as they travel. DMS will assist in traffic management for special events, aid tourists unfamiliar with the area, and provide information on delays and alternate routes during congested periods and in the event of traffic incidents. The expected cost for these improvements is \$1,200,000.

Kiosks at major public venues. The NCDOT and the cities in the Asheville Region will develop and install five (5) kiosks that use web-based technologies to link to websites in the area that display local traffic and event information. In addition, these kiosks will display information of interest for tourists, including destinations, lodging, restaurants, and information centers. Potential locations include regional malls, rest areas, visitors' bureaus, chambers of commerce, arenas and coliseums, hotels, racetracks, convention centers, and others.

Kiosks provide NCDOT the opportunity to enter into ventures with private entities in two ways. The first is by selling or leasing kiosks at locations that are not public facilities. This may include large employers, malls, or hotels. Also, if additional kiosks are requested at locations, they may be sold or leased as well. The second opportunity is to permit the generation of kiosk operating revenue by either selling advertising or licensing the kiosks. This would permit NCDOT to recover some of the costs of providing the data and hosting websites.

The cost of installing 5 kiosks throughout the Asheville region is approximately \$300,000. There are additional costs associated with the long-term operations of kiosks, especially as more are added, for updating information and adding bandwidth.

The development costs of the kiosk content needs to be shared among the many interested parties. Traffic and transit data is only a small portion of the information that is available, and is typically the least used. The most used information is concerning local interests and directions to destinations. Therefore, the development costs of the content need to be borne by those who will benefit the most: tourist destinations, restaurants, and hotels.

Expand the traveler information system. The traveler information system identified as a short-term project limits the user input to selecting bus routes and identifying “hot spots” along major routes. As a long-term project, NCDOT will expand the system to provide additional real-time information, such as transit arrival, estimated travel times and video images from Asheville. The expansion of this system, with regard to integration and website development (including hardware) is estimated to cost \$1,500,000.

511 traveler information number. As part of a national program, a traveler information line will be set up using the telephone number 511. This number would operate much the same way as 911 provides emergency police service to callers, except the number would allow any caller to get instant, real-time information on directions to unfamiliar destinations, local highway conditions, weather, traffic delays, and public transit schedules.

Project Summary

A summary of the aforementioned projects and their estimated cost are shown in **Table 8**.

Table 8. Summary of ITS Projects and Estimated Costs (based on year 2001 dollars)

| Short-Term Projects | | | Long-Term Projects | | |
|---|--|--------------|--|--|--------------|
| Description | | Cost (\$000) | Description | | Cost (\$000) |
| ATMS | | | ATMS | | |
| S-1 | Incident Management Plan | *** | L-1 | DMS Expansion | \$1,200 |
| S-2 | IMAP in Asheville | \$400 | | | |
| S-3 | Dynamic Message Signs | \$400 | | | |
| S-4 | Highway Fog Warning System | \$600 | | | |
| Subtotal | | \$1,400 | Subtotal | | \$1,200 |
| APTS | | | APTS | | |
| S-5 | Advanced Transit System | \$250 | L-2 | Transit System Expansion | |
| Subtotal | | \$250 | Subtotal | | \$0 |
| ATIS | | | ATIS | | |
| S-6 | Additional HAR Sites | \$120 | L-3 | Kiosks at Major Public Venues | \$300 |
| S-7 | Regional Traveler/Transportation Website | \$50 | L-4 | Expand the Traveler Information System | \$1,500 |
| S-8 | Traveler Information System | \$100 | L-5 | 511 Traveler Information Number | ** |
| S-9 | Web-Based Roadway Information | *** | | | |
| Subtotal | | \$270 | Subtotal | | \$1,800 |
| CVO | | | | | |
| S-10 | Web Credentials | *** | | | |
| S-11 | Truck Presence Detection | *** | | | |
| S-12 | Mobile Inspection | *** | | | |
| Subtotal | | \$0 | | | |
| Safety | | | | | |
| S-13 | Automated Work Zones | *** | | | |
| Subtotal | | \$0 | | | |
| Total Short-Term | | \$1,920 | Total Long-Term | | \$3,000 |
| Anticipated Annual O&M Costs (8% of Total Short-Term) | | \$154 | Anticipated Annual O&M Costs (8% of Total Long-Term) | | \$240 |
| Total 20-year Estimated Costs | | | | \$4,920 | |
| **No direct costs | | | | | |
| ***Costs are borne internally by NCDOT | | | | | |

Operational Concepts

A primary objective with ITS deployments is to provide operational coordination across jurisdictional lines. Unlike the Triad, Triangle, and Metrolina regions-where there are large regional operations centers either existing or planned, and there are multiple local jurisdiction - the Asheville region only consists of the City of Asheville, with smaller ITS deployments in surrounding counties and towns. Although this makes an operational plan easier in that there is only one entity with traffic management responsibilities, there is no local, regional backup to either the overall system or the individuals responsible for day-to-day operations.

In addition to traffic management needs, the Asheville ITS Planning Region will benefit greatly from an integrated emergency response and dispatch system that incorporates all of the local systems. Local operations and database management benefits will be magnified by the sharing of information.

Following the development of this deployment plan, a regional operations plan that ties in operating procedures for systems throughout the region. This plan will include an incident management plan, with set responses for incidents throughout the region, procedures on working with various emergency personnel, and directions on how to work with the many different traffic management and signal systems in the region. This plan needs to be tied into the statewide plan to provide for the backup for both the system and personnel on a statewide level.

The agencies in the Asheville Region, and their primary responsibilities are:

- NCDOT – Asheville area
 - Freeway Management
 - Regional Traveler Information – Website development, kiosk traffic information, etc.
 - HAR
 - Major Event/Incident Coordination
- NCDOT – Statewide
 - Statewide Coordination
 - Statewide Traveler Information – Website, etc.
- City of Asheville
 - Traffic Signal Control/Systems
 - Asheville Transit System
 - Traveler Information – Local issues and attractions, local traffic information, etc.
- City of Asheville Police Department
 - Emergency Management
 - Enforcement
- Buncombe County Sheriff
 - Emergency Management
 - Enforcement

Benefits of ITS Systems

The benefits of ITS deployment are difficult to measure by simple quantitative analysis. An integrated ITS deployment program can include safety improvements, delay reduction, cost savings, capacity improvements, customer satisfaction, energy consumption reduction, and positive environment impacts. Municipalities throughout the United States are already seeing benefits from existing deployments. This benefit analysis reviews the existing deployments for various short and long term projects recommended for the Asheville Region and provides real-world examples of benefits being realized by other municipalities. Quantifiable benefits for air quality monitoring can be obtained by following the Federal Highway Administration August 1999 report *Off-Model Air Quality Analysis – A Compendium of Practice* which is included in the Appendix. The following examples illustrate true potential application of the Asheville Region ITS deployment plan.

Freeway/Incident/Event Management

There are three major ITS functions that make up Freeway Management Systems (FMS). These include monitoring and controlling freeway operations and providing current traffic information to motorist. The most common ITS devices used for monitoring and control include camera surveillance and ramp metering. Where variable message signs, updated web sites and highway advisory radio are commonly used to provide traffic information to the motorist. A traffic management center (TMC), the control center for the various ITS deployments, is responsible for monitoring freeway conditions and dispersing the information to motorist. Although FMS are most effective when used in conjunction with incident management and transit management systems, when used by themselves, they can make a substantial difference in increasing average speeds, reducing travel time, minimizing stop delays and reducing accident rates.

IMAP

The Incident Management Assistance Patrol are emergency traffic patrol vehicles equipped to aid minor breakdowns, push or tow vehicles, and reposition and move trailers. The purpose of this program is to respond as quickly as possible to debilitated vehicles to minimize the impact on traffic flow. When additional equipment is added such as computer aided dispatch systems, global positioning systems and mobile changeable message signs, patrols can get the job done faster. Programs like these also benefit the environment by restoring traffic flow and minimizing idling vehicle emissions. Additionally, this program provides an added measure of safety and security to the public.

Refer to the *Off-Model Air Quality Analysis: A Compendium of Practice* included in the appendix of this report for analyzing air pollution reduction with incident management.

Transit

Transit Management System (AVL, etc.)

The implementation of a complete Transit Management System has shown to increase ridership and reduce costs for transit operators. For example, Winston-Salem, North Carolina evaluated a computer aided dispatch and scheduling system on a 17 bus fleet. Within six months the ridership grew from 1,000 to 2,000 users and vehicle miles per passenger-trip grew 5%. Moreover, operator expenses dropped 2% per passenger trip and there was a decrease in passenger wait time by 50%.⁴

Transit management systems also provide more efficiency for transit operations and may enable transit operators to streamline operations. Kansas City, Missouri was able to reduce 10% of the equipment required for some bus routes by using AVL/CAD while maintaining customer service. In addition, the use of an AVL system allowed Kansas City to eliminate seven buses out of a 200 bus fleet, thus allowing Kansas City to recover its investment in the AVL system within two years.⁵

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Traveler Information

Web/Roadway Traveler Information System

Providing traveler information over several modes of travel can be beneficial to both traveler and service providers. Several transit agencies as well as some Traffic Management Centers have started using kiosks, local cable television and web sites to disperse information about current traffic conditions and transit schedules. This enables travelers to make more informed decisions for trip departures, routes and modes of travel. They have been shown to increase transit usage, and may help reduce congestion when travelers select alternate routes or postpone trips.

An example of how effective the traveler information system can be is illustrated by the surveys performed in the Seattle, Washington and the Boston, Massachusetts areas. These surveys indicated that when provided with traveler information, 30%-40% of travelers adjusted their travel. Of those that changed their travel, 45% of travelers changed their route of travel and 45% changed their time of travel, while the remaining 10% changed their mode of travel.

Traveling information systems are believed to greatly impact vehicle emissions as well. In 1999, it was projected that 96,000 callers would use the SmarTraveler system in Boston on a daily basis. To estimate the impact the SmarTraveler system would have on emissions, the MOBILE5a model was used but included only 30% of the projected 96,000 daily callers. The results from the model concluded that on a daily basis there would be an average reduction by 25% of volatile organic compounds, as well as 1.5%

⁴ Stone, J., "Winston-Salem Mobility Management: An Example of APTS Benefits, "NC State University, 1995.

⁵ Giugno, M., Milwaukee County Transit System, July 1995 Status Report.

of NO_x and 33% of CO as compared to daily vehicle emissions not influenced by the SmarTraveler system⁶.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Other ITS Benefits

Arterial Management Systems

Arterial Management systems are used to manage the traffic and control of arterial roadways through signal coordination, surveillance, sign control, and motorist informational systems. Traffic management centers also play an important role in these systems by monitoring and controlling traffic conditions and dispersing information to motorist about the arterial roadways. There have been numerous evaluations on the arterial management systems operating in cities around the world that have determined that these systems produce substantial environmental benefits by reducing vehicle stops, which then creates a reduction in fuel consumption and vehicle emissions. Additionally, arterial management systems have improved methods for reducing incident delays, increasing average speeds, as well as lowering accident rates. Arterial management systems are most effective when used in conjunction with incident management and transit management systems. Moreover, when multiple operational components are implemented such as surveillance, motorist informational systems as well signal coordination, a traffic management center has greater adaptive capabilities and control to improve changing traffic conditions.

A good example of how arterial management systems can substantially improve traffic conditions is demonstrated by a 1994 evaluation of a computerized signal control in the City of Los Angeles. This system had been in operation since 1984 and as of 1994 it was comprised of 1,170 intersections and 4509 detectors for signal timing optimization. The results of this evaluation reported a 13% decrease in vehicle stops, 18% reduction in travel time, 16% in average speed, 13% decrease in fuel consumption and 14% decrease in emissions.⁷

There are many different types of ITS devices that produce successful arterial management systems. In Fairfax City, Virginia a program was started that used automated cameras to record violations and ticket violators in an effort to reduce intersection accidents. It was reported that after the program was implemented there was a 35% reduction of accidents at intersections with traffic lights. Arterial management systems can increase overall capacity of existing roadways, increase road safety for motorist and improve the environment at a justifiable cost.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of signal improvements on air pollution.

⁶ Tech Environmental, Inc., Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, July 1993.

⁷ City of Los Angeles Department of Transportation, "Automated Traffic Surveillance and Control (ATSAC) Evaluation Study," June 1994.

National Architecture Compliance

The development of the short- and long-term projects is the final step before the development of the regional architecture. The regional architecture that is used is a derivative of the national architecture as previously discussed. However, the regional architecture includes multiple figures and tables that document the relationships between various components, control centers, and agencies. The regional architecture documentation and all associated figures are provided as a supplement to this report.

The intent of the regional architecture is to document the flows of data between the many elements that are currently and will ultimately be deployed throughout the Asheville Region. Based on the regional architecture, as individual projects are developed, they can be incorporated to ensure that information is shared throughout the region.

The architecture database that has been prepared for this report is not intended to sit on a shelf. Rather, it is intended to be a living database that is updated as projects are deployed or new projects are planned.

Standards

In addition to compliance with the National Architecture, USDOT has been working with the industry to develop standards for use within the ITS community. The most common standard that has been deployed to date is the National Transportation Communication for ITS Protocol (NTCIP) for traffic signals. As of 1999, NTCIP was the only widely adopted standard. However, there are many more that are being developed and approved nationally for use in ITS. The standards that have been identified are:

Relevant Standards Activities

| Organization | Standard Name | Standard Number |
|--------------|--|-----------------|
| AASHTO | NTCIP - Application Profile for File Transfer Protocol (FTP) | 2303 |
| AASHTO | NTCIP - Application Profile for Trivial File Transfer Protocol | 2302 |
| AASHTO | NTCIP - Applications Profile for Data Exchange ASN.1 (DATEX) | 2304 |
| AASHTO | NTCIP - Base Standard: Octet Encoding Rules (OER) | 1102 |
| AASHTO | NTCIP - Subnetwork Profile for Ethernet | 2104 |
| AASHTO | NTCIP - Subnetwork Profile for Point-to-Point Protocol using RS 232 | 2103 |
| AASHTO | NTCIP Guide | 9001 |
| AASHTO | NTCIP - Object Definitions for Video Switches | 1208 |
| AASHTO | NTCIP - Simple Transportation Management Protocol (STMP) | 1103 |
| AASHTO | NTCIP - Profiles - Framework and Classification of Profiles | 8003 |
| AASHTO | NTCIP - Data Dictionary for Closed Circuit Television (CCTV) | 1205 |
| AASHTO | NTCIP - Applications Profile for Common Object Request Broker Architecture (CORBA) | 2305 |
| ASTM | Standard Specification for DSRC - Physical Layer 902-928 MHz | PS 111-98 |
| ASTM | Standard Specification for DSRC - Data Link Layer | Draft Z7633Z |

| | | |
|---------|--|----------|
| EIA/CEA | Data Radio Channel (DARC) System | EIA-794 |
| EIA/CEA | Subcarrier Traffic Information Channel (STIC) System | EIA-795 |
| ANSI | Commercial Vehicle Safety Reports | TS284 |
| ANSI | Commercial Vehicle Safety and Credentials Information Exchange | TS285 |
| ANSI | Commercial Vehicle Credentials | TS286 |
| IEEE | Standard for Common Incident Management Message Sets (IMMS) for use by EMSs | P1512 |
| ITE | Advanced Traffic Controller (ATC) Application Program Interface (API) | 9603-1 |
| ITE | ATC Cabinet | 9603-2 |
| ITE | Advanced Transportation Controller (ATC) | 9603-3 |
| ITE | Message Set for External TMC Communication (MS/ETMCC) | TM 2.01 |
| ITE | Standard for Functional Level Traffic Management Data Dictionary (TMDD) | TM 1.03 |
| IEEE | Survey of Communications Technologies | ITSPP#5 |
| IEEE | ITS Data Dictionaries Guidelines | ITSPP#6A |
| AASHTO | NTCIP - Simple Transportation Management Framework (STMF) | 1101 |
| AASHTO | NTCIP - Class B Profile | 2001 |
| AASHTO | NTCIP - Global Object Definitions | 1201 |
| AASHTO | NTCIP - Object Definitions for Actuated Traffic Signal Controller Units | 1202 |
| AASHTO | NTCIP - Object Definitions for DMS | 1203 |
| AASHTO | NTCIP - Point to Multi-Point Protocol Using RS-232 Subnetwork Profile | 2101 |
| IEEE | Guide for Microwave Communications System Development | 1404 |
| IEEE | Recommended Practice for the Selection and Installation of Fiber Optic Cable | P1454 |
| IEEE | Message Sets for DSRC ETSM & CVO | 1455 |
| IEEE | Standard for Message Set Template for ITS | P1488 |
| IEEE | Standard for Data Dictionaries for ITS | 1489 |
| AASHTO | NTCIP - Transportation System Sensor Objects | 1209 |
| AASHTO | NTCIP - Data Collection & Monitoring Devices | 1206 |
| AASHTO | NTCIP - Application Profile for Simple Transportation Management Framework (STMF) | 2301 |
| AASHTO | NTCIP - Internet (TCP/IP and UDP/IP) Transport Profile | 2202 |
| SAE | Truth-in-Labeling Standard for Navigation Map Databases | J1663 |
| SAE | Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications | J1708 |
| SAE | Information Report on ITS Terms and Definitions | J1761 |
| SAE | A Conceptual ITS Architecture: An ATIS Perspective | J1763 |
| SAE | ISP-Vehicle Location Referencing Message Profiles | J1746 |
| SAE | On-Board Land Vehicle Mayday Reporting Interface | J2313 |
| SAE | Information System (ATIS) Data Dictionary | J2353 |
| SAE | Advanced Traveler Information System (ATIS) Message Set | J2354 |
| SAE | ITS Data Bus Architecture Reference Model Information Report | J2355 |
| SAE | Standard for Navigation and Route Guidance Function Accessibility While Driving | J2364 |
| SAE | ITS Data Bus Protocol - Link Layer Recommended Practice | J2366-2 |
| SAE | ITS Data Bus Gateway Recommended Practice | J2367 |
| SAE | ITS Data Bus Conformance Test Procedure | J2368 |
| SAE | Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media | J2369 |
| SAE | Field Test Analysis Information Report | J2372 |
| SAE | Stakeholders Workshop Information Report | J2373 |
| SAE | National Location Referencing Information Report | J2374 |

| | | |
|-----|--|---------|
| SAE | ITS In-Vehicle Message Priority | J2395 |
| SAE | Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.) | J2396 |
| SAE | Adaptive Cruise Control: Operating Characteristics and User Interface | J2399 |
| SAE | Forward Collision Warning: Operating Characteristics and User Interface | J2400 |
| SAE | ITS Data Bus Data Security Services Recommended Practice | J1760 |
| SAE | ITS Data Bus Protocol - Physical Layer Recommended Practice | J2366-1 |
| SAE | ITS Data Bus Protocol - Thin Transport Layer Recommended Practice | J2366-4 |
| SAE | ITS Data Bus Protocol - Application Layer Recommended Practice | J2366-7 |
| ITE | TCIP - Control Center (CC) Business Area Standard | 1407 |
| ITE | TCIP - Common Public Transportation (CPT) Business Area Standard | 1401 |
| ITE | TCIP - Fare Collection (FC) Business Area Standard | 1408 |
| ITE | TCIP - Framework Document | 1400 |
| ITE | TCIP - Incident Management (IM) Business Area Standard | 1402 |
| ITE | TCIP - Onboard (OB) Business Area Standard | 1406 |
| ITE | TCIP - Passenger Information (PI) Business Area Standard | 1403 |
| ITE | TCIP - Scheduling/Runcutting (SCH) Business Area Standard | 1404 |
| ITE | TCIP - Spatial Representation (SP) Business Area Standard | 1405 |
| ITE | TCIP - Traffic Management (TM) Business Area Standard | TS 3.TM |

The first priority with the continued deployment in the Asheville Region is to comply with national standards. However, a number of choices were made in the development and deployment of the TRTMC and other systems over the past few years that will affect the standards that are chosen. An example is emergency vehicle preemption. To date, all of the deployments for emergency vehicle preemption have used 3M Opticom® equipment. This system uses a proprietary interface that is not standard. To change this to an open standard driven system would require that all of the existing Opticom® equipment either be replaced or upgraded (if possible). This is not feasible. In instances such as this, the existing system will be maintained.

Regional Communication Architecture

Based on the short- and long-term projects, the key component of the Asheville Region ITS Deployment plan is to develop a central database of traveler information to be disseminated to motorists throughout the region. This regional system, with the various inputs and outputs is shown in **Figure 11**.

The concept of this architecture is that the City of Asheville controls a majority of the traffic operations equipment through the region, and, therefore, has easy access to a majority of the traffic information generated by these elements. External inputs, such as the IMAP program and the NCDOT statewide program office needs to be accessed, but not generated or stored locally.

The concept of the architecture is that the City of Asheville and NCDOT share information both regionally and, to some extent, statewide to provide information that can be easily accessed from one concise front end. There are two options to operate a regional traveler information system: central and virtual. These two concepts are shown in **Figure 12**.

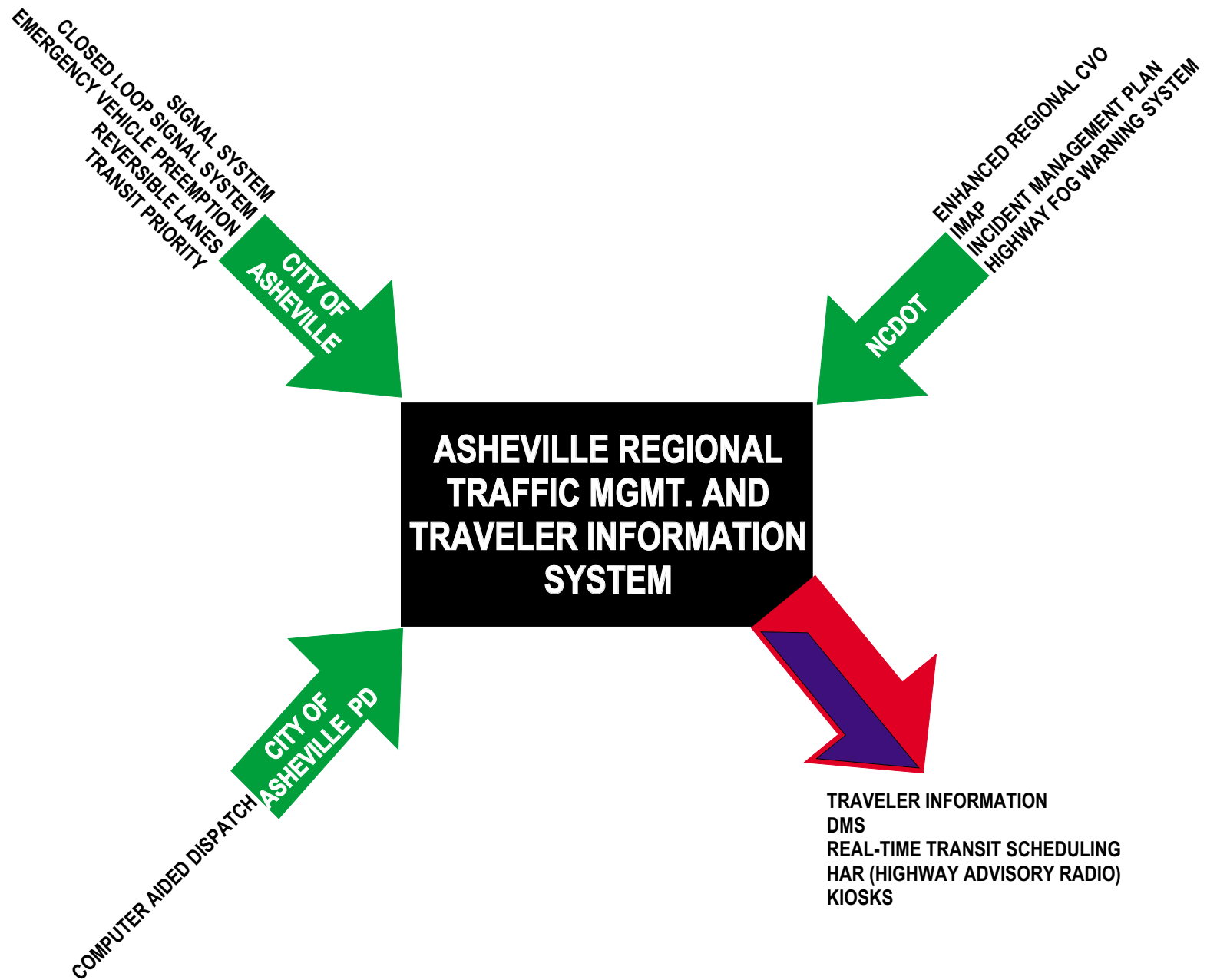
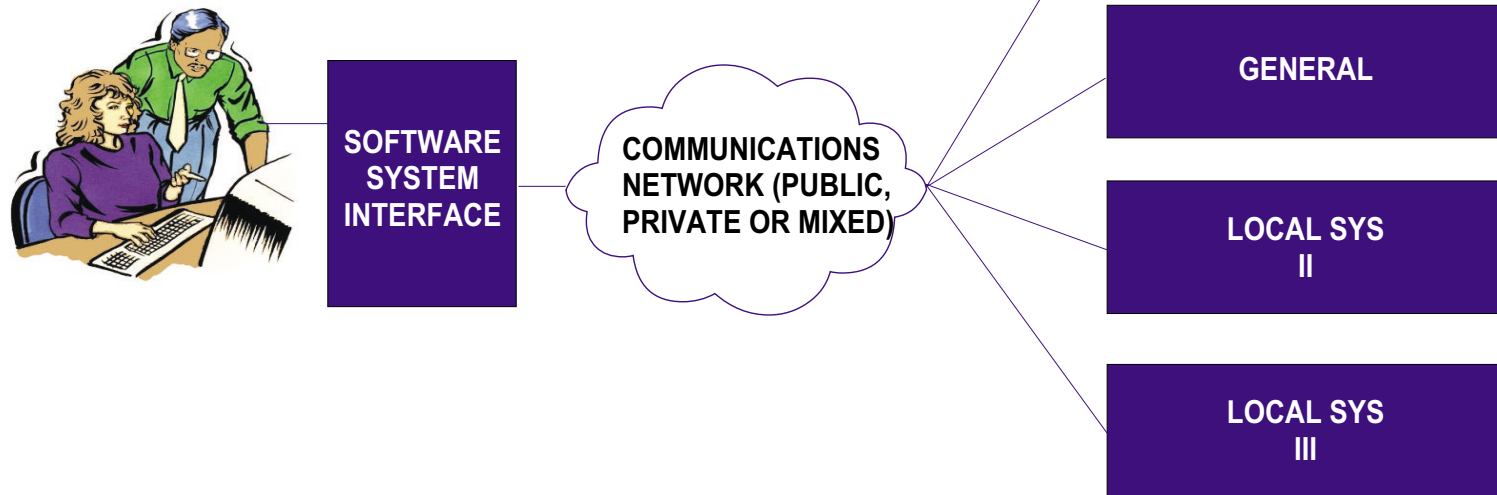


FIGURE 11 GENERIC REGIONAL ARCHITECTURE

VIRTUAL



CENTRAL

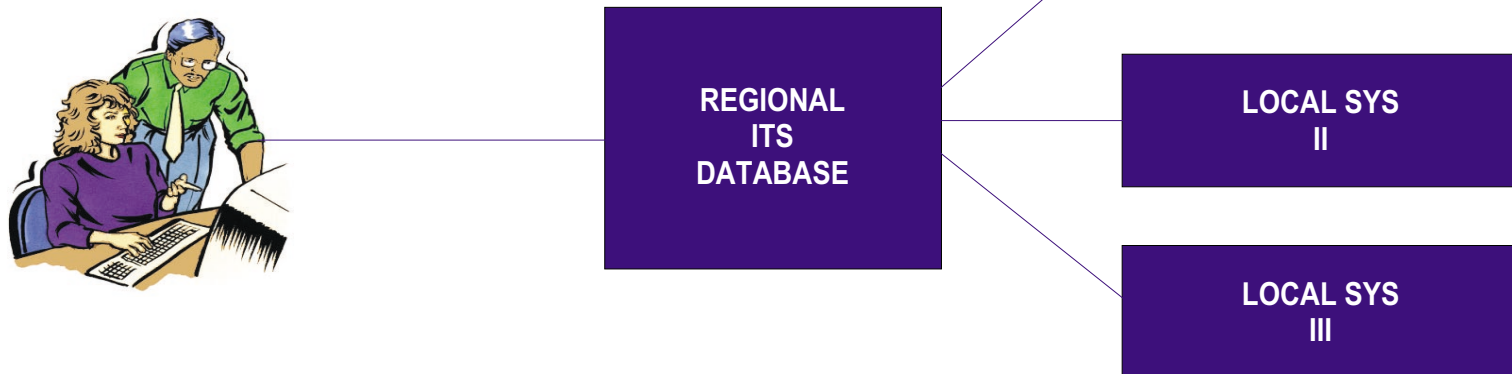


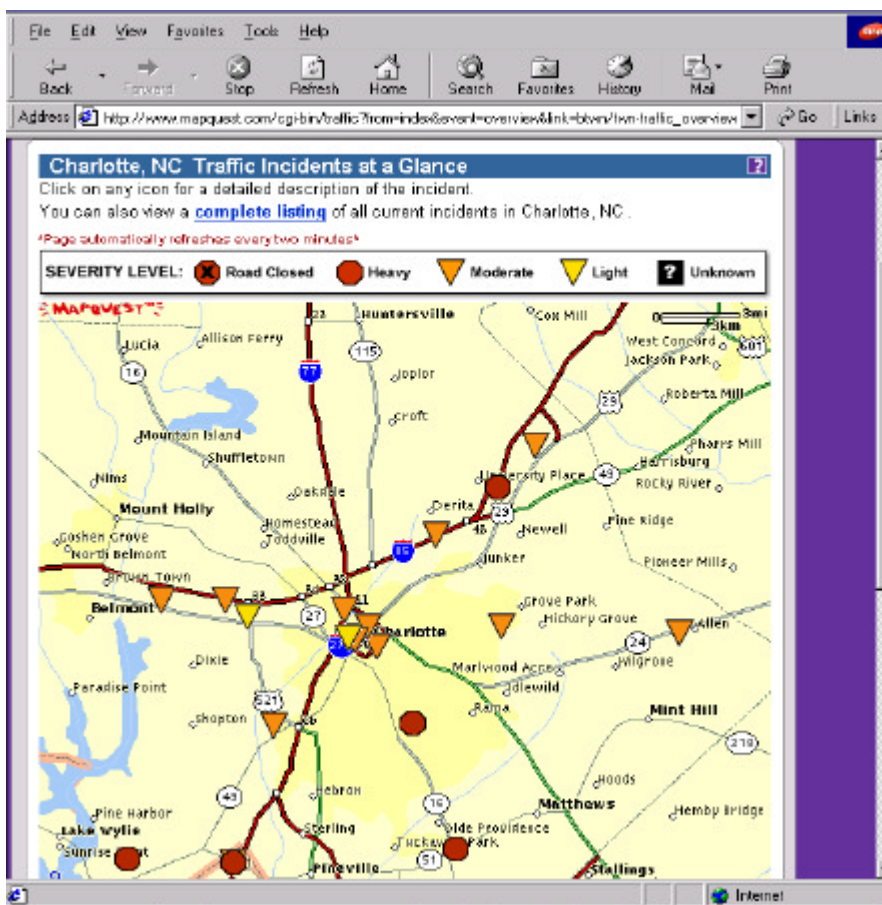
Figure 12 Central vs. Virtual Information System

Central Information System

A central system is the more expensive of the two to design, build, operate, and maintain. A central system requires that all the data, video, and other information be brought to one central location for dissemination. For instance, the NCDOT could house the information system. This system would store all of the information, both data and video, and disseminate it as needed. A type of central system is provided by MapQuest at www.mapquest.com. MapQuest's traveler information pages get data from the DOT and provide it on the MapQuest. A sample image from MapQuest is provided for the Charlotte areas in **Figure 13**.⁸

MapQuest is a sample of a third party using available information to document and present traffic conditions in real time. Other web sites with similar information include www.smartroutes.com, www.strategy.com (in development), and others.

Figure 13. Sample MapQuest Image



⁸ MapQuest is just one of many private sector companies repackaging ITS information for profit. Others include Yahoo! (traffic.yahoo.com), SmartRoutes (www.smartroutes.com) and TrafficStation (www.trafficstation.com).

The advantage of a central system is that it provides consistency to the end user in both the look and feel, and also in the data and video provided. A central system provides greater control over the information, in that one agency, organization, or even person has the ultimate responsibility for all of the system's components.

The key disadvantage is the cost needed to design, construct, operate, and maintain such a system. Where a virtual system requires that the end user have an adequate connection to the regional and local sites, the central system requires that there be a permanent connection from the central system to each of the local sites. In essence, the responsibility of data and video dissemination falls on whoever is operating the central system.

Virtual Information System

A virtual information system requires less front-end expense than the central system, but also has issues with compatibility and consistency. A virtual system provides a front-end for the user from which he or she can select the information that is desired. When selected, however, the user connects directly to the local system from which information is requested. The only information stored at the central location is the front-end and generic regional information. All of the specific data and video can be accessed from each of the local sites.

The advantage of a virtual system is that it provides all of the same information as a central system, but at a lower front cost. The only requirements for the virtual system are solely a link from the central system to each of the local systems. The bandwidth for the local systems to transmit this information to the end user is the responsibility of the local agencies. A virtual system is very similar to the World Wide Web. A site like www.yahoo.com provides traffic and traveler information through links to the various sites. This is similar to a virtual system.

The key disadvantage of the virtual system is the consistency amongst the sites, both in terms of look and feel, as well as status. Different internet sites have different methods of presenting information. Unlike a central system where one person or group has control of the look of a site, a virtual system has different groups of people responsible for each of the local sites, which can confuse users. This problem can be eliminated by standardizing the front ends of the various systems.

It is important that the status of the varying sites be consistent. Where the central system has all of the data and information stored and processed locally, the virtual system relies on other sites to be operational, up to date, and consistent. If it is not, users will stop visiting the site for traffic and traveler information.

Regional Architecture Recommendation

The Asheville Regional plan focuses on improving the existing ITS deployments and enhancing traveler information. This deployment has promoted the deployment of a centralized communication system. Although there will be a number of virtual elements, specifically regarding information from NCDOT both regionally and statewide, the vast majority of input into the system are currently centralized, and should remain that way.

Communication System

The regional communication is limited because of the deployments, both existing and planned, and the geography of the region. The system will encompass the existing communications between Asheville and the existing ITS elements, with new deployments providing or improving communication as necessary. The regional communication system is shown in **Figure 14**.

Additional infrastructure desired for this project will be developed as part of the short- and long-term projects. Each project that requires communications should be deployed with the intent of expansion of communications, since the addition of fiber for the regional system adds an insignificant cost (The vast majority of the cost of installing fiber optic cable is in the trench, conduit and labor to install the cable. Adding additional strands only adds an insignificant amount per linear foot of cable).

Communications Assessment

The only regional communication that is required for the short-and long-term ITS deployment in the Asheville Region is the communication necessary to connect the Asheville Region into the NCDOT statewide system. A full-time connection is recommended between the NCDOT offices in the Region and Asheville to share video and data. The statewide standard that is being recommended from each region is a 3 Mbps (two T-1 Lines) connection. This will permit, as described below, multiple low frame rate video channels to be transmitted across the network until a statewide network is fully developed. The communications plan is shown in **Figure 15**.

The statewide link is necessary for several reasons, most notably to view traffic in the Metrolina, Triangle, Triad and other regions, and for those regions to view traffic in the Asheville Region. Additionally, traffic in the Asheville Region can significantly affect the I-40 corridor, and vice versa. Traffic monitoring and control is a local issue with regional and statewide impacts. For that reason, transmitting basic data and video images to a statewide network does not require the same quality as for local information. Video images from Asheville to the NCDOT is recommended to be limited to 384 Kbs.

The statewide link is recommended to be a leased network at this time. There are many states in the process of developing statewide fiber optic deployments from border to border along the major freeways with assistance from private partners. In lieu of this occurring in North Carolina, a statewide leased network is sufficient to provide basic data and video transmission. It is recommended that a total of 2 T-1 connections be provided from the Asheville region to NCDOT's MRTMC. The cost to lease the bandwidth required to connect these two centers would be approximately \$30,000 per year, in addition to a one-time setup and installation cost of approximately \$20,000.

Video images can be broadcast or transmitted at different data rates, depending on the quality desired by the viewer. The higher the data rate, the better the quality. As data rates decrease, images tend to become either smaller or jumpy. It is recommended that for center to center video, a data rate of between 3 and 6 Mbs (Megabits per second) be used. This rate will allow full frame, full motion video with little or no "jumping."

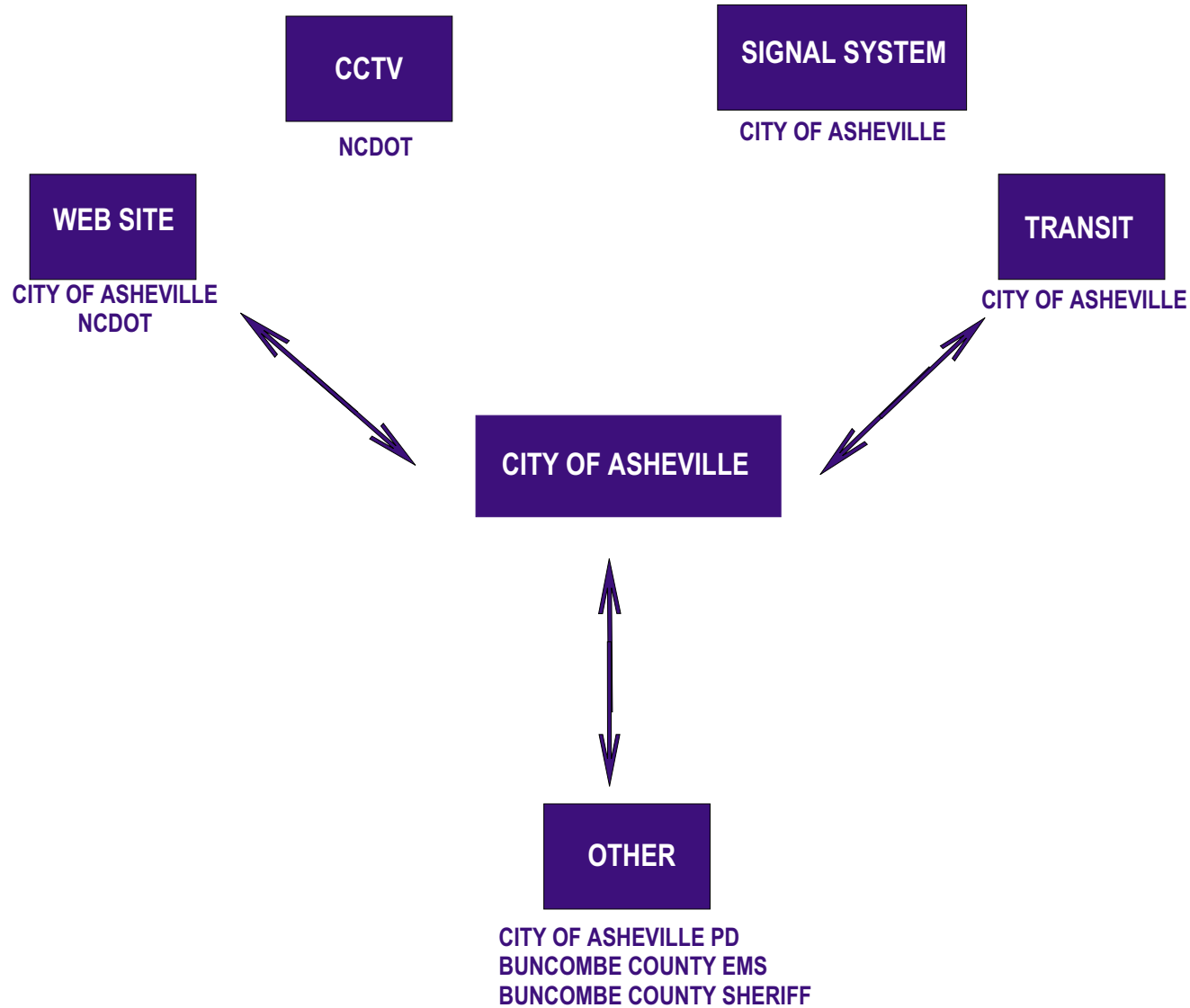


FIGURE 14 PROPOSED COMMUNICATION TOPOLOGY

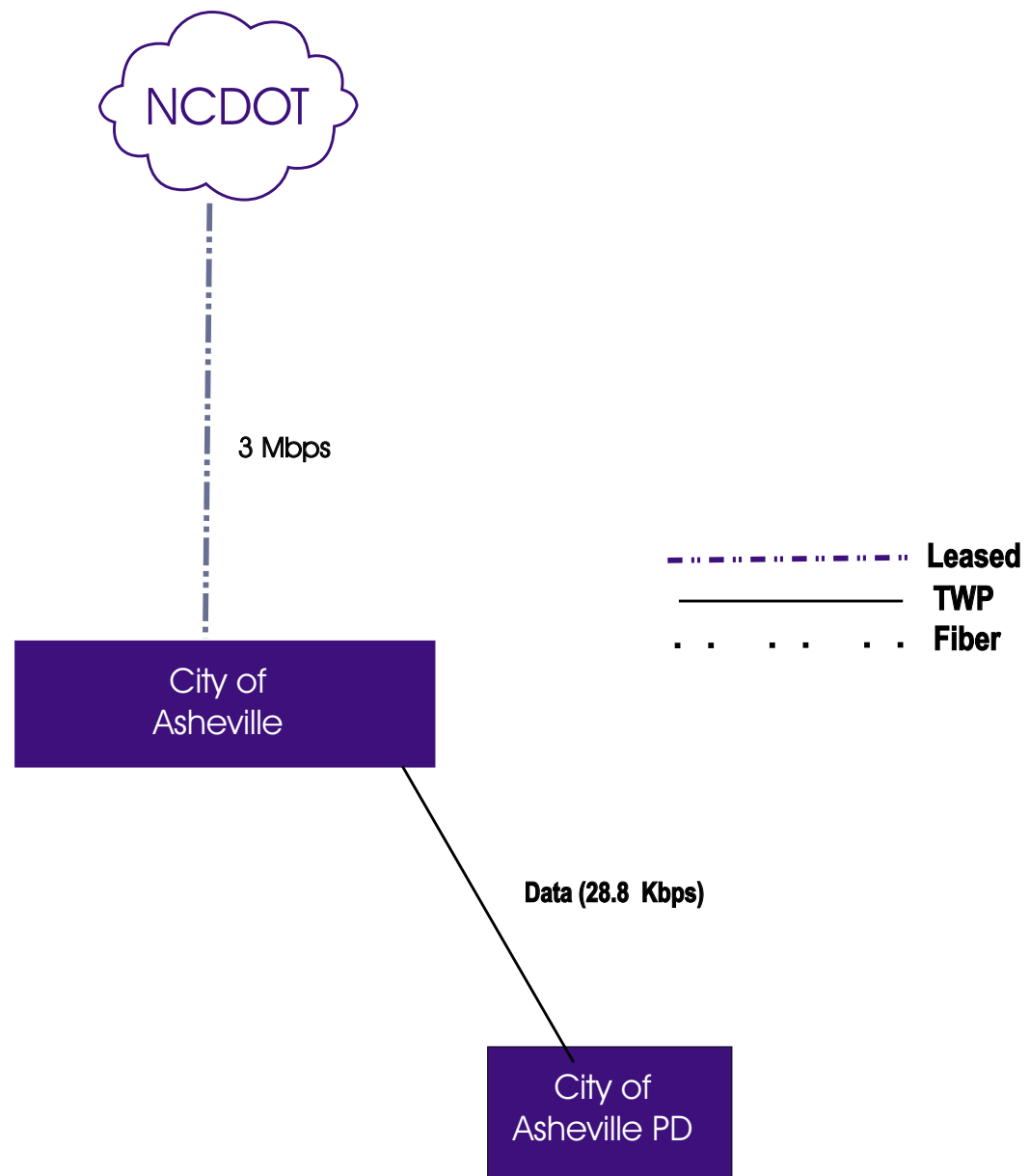


FIGURE 15 ASHEVILLE REGION COMMUNICATION PLAN

Video between Asheville and the rest of the state can vary depending on the bandwidth available, and expand as the communication infrastructure increases. For the purposes of traffic control video, a low data rate of 1.5 Mbs is reasonable, since it can be transmitted over one leased T-1 line. The video transceivers and multiplexers available today allow the data rate to be changed, so as different communication options become available, the only changes necessary in the end equipment is in the software to convert the data rate, and in the network interface to change connection types.

Data transmission of traffic information is significantly reduced from the needs of video transmission. Typical data from a traffic signal system is constant, but not at a high data rate (most controllers are limited to data rates as low as 14.4 or 28.8 Kbs. Data from other sources, such as traffic data count stations, DMS and HAR does not require continuous communications, rather the data (or voice for HAR) is sent in a burst. The more bandwidth available, the shorter the burst.

Communications between the City of Asheville and the surrounding communities is recommended to continue using standard telephone service. Although the information collected by the various elements encompassing the ITS deployment in the Asheville Region can impact these other municipalities, a majority of the impacts and response will be handled by the City of Asheville. The bandwidth necessary to transmit basic data between Asheville and these surrounding communities will be very limited. A majority of the incident responses that require multiple jurisdictions will be coordinated by the City of Asheville or the police departments. Communications during these events will occur via either radio or telephone. A standard telephone line connecting these facilities will permit the exchange of basic data and still frame video images.

APPENDIX

Meetings

Summits

NIA Compliance

**FHWA: Off-Model Air Quality Analysis – A
Compendium of Practice – August 1999**